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COSAGE USER'S MANUAL

VOLUME I - MAIN REPORT

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PREPARED BY
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13. ABSTRACT (Maximum 200 words)

The Combat Sample Generator (COSAGE) was constructed so that a number of synergistic effects relating to the joint action of combat arms could be simulated within the same model. For example, direct support artillery supporting armor and infantry in battle could not be simulated prior to the introduction of COSAGE. The same is true for the COSAGE simulation of Army aviation, engineers, and USAF functions.

Throughout the past decade, COSAGE has been used to support requirements studies such as those involving the need to determine "ammunition requirements" for near-term and outyear scenarios. COSAGE has also been employed in capability studies and in quick reaction, real-time direct support for such operations as DESERT SHIELD and DESERT STORM.

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COSAGE USER'S MANUAL*

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. PURPOSE. The purpose of the Combat Sample Generator (COSAGE) User's Manual is to document the functions, logic, and structure of the software program modules and subroutines that compose the COSAGE Model. This documentation covers the data base, the runstreams, input data descriptions and samples, and sample output data in enough detail to permit a potential user to prepare the input data files and execute the programs.

1-2. SCOPE. The COSAGE User's Manual is a procedural guide for division combat modelers and tactical analysts. It provides an overview of the COSAGE Model and the methods and procedures for developing, simulating, and analyzing division combat.

1-3. ORGANIZATION. The COSAGE User's Manual is a three-volume publication. Volume I provides a description of the COSAGE Model and program logic for indirect fire, direct fire, small unit engagements, and other combat support systems to the individual battles. Volume II documents the data base organization, file development methodology, analysis techniques, input data structure, and output reports. Volume III illustrates application issues--problems and answers.

1-4. SECURITY. The individual software components (programs) are cataloged as indicated under the detailed descriptions for each access. Users are asked not to modify or edit (write) in the program files. In the event alteration is required for a specific purpose, a potential user should copy the program to a file under his/her user identification and then edit the file as desired. In the event of error detection during use, the user is requested to note the error by program line and forward the proposed correction to the program custodian, so that the record program may be updated. Test (sample) data, either input or output, and the programs contained herein are unclassified. Users must apply the appropriate security classifications to their data files and are responsible for the safeguarding of printed matter in accordance with CAA policy.

1-5. TERMS AND ABBREVIATIONS. Acronyms are used throughout to facilitate communication of words and analytical expressions common to the methodology and military operations research. The Glossary to this manual contains a complete listing of these expressions. In addition, the definition of the expression, followed by the acronym or term in parentheses, is used throughout the manual on the first occurrence of its use.

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*Fourth revision.

Section II. STUDY DEVELOPMENT

1-6. STUDY SPONSOR. Generally, COSAGE simulations are prepared to support a study required by the Army Staff or some other military organization. There are occasions, however, when COSAGE supports internal CAA initiatives. In either situation, the requirement is established through a study directive.

1-7. STUDY DIRECTIVE. The study framework is specified in the directive from the study sponsor. The directive provides the study purpose, objectives, scope, assumptions, limitations, and guidance. Specific information is provided on the study year, theater of operations, scenario, and forces involved.

1-8. STUDY DIRECTOR. A study director is designated by CAA to develop the combat simulation, generally at theater level. The study director coordinates with the study sponsor and directs the activities and support functions within the agency.

CHAPTER 2

THE COSAGE MODEL

Section I. MODEL SUMMARY

2-1. GENERAL

a. COSAGE is a two-sided, symmetrical, high-resolution, stochastic simulation model of combat between two forces.

b. Typically, the Blue force is sized as a division, and the Red force is scaled from a fraction of a division to a combined arms army. The model simulates periods (normally 48 hours) of combat and produces expenditures of ammunition by round type and losses of personnel and equipment. Maneuver unit resolution is typically down to Blue platoon versus Red company, but may be changed as needed. In the case of close combat, resolution is to the individual equipment and weapon level.

c. The input data describe the forces; their organization, equipment, weapons and personnel; the characteristics of their weapons and equipment; appropriate probability values used during the simulation; priorities, sequences, and rules of engagement; sensor definitions; and operational concepts.

d. COSAGE is extremely flexible in its ability to portray forces, organizations, tactical employment doctrine and techniques, and theaters of operation. It simulates the average day of combat for a division in a tactical operation. Knowledgeable, thoughtful use of the model capabilities will permit the realistic portrayal of the major aspects of combat.

e. COSAGE is a discrete event simulation, with stochastic phenomenon modeled through events and processes. Events are called into execution by the model logic and scheduled to occur at a computed future time in the simulation. During one event, another event (same or different type) may be created and scheduled, or another part of the program may be called into execution. Chapter 3 provides a brief description of the type events and processes.

f. Events are discrete in that they occur at a specific time. Processes occur over a period of time and are controlled by the model clock. Processes are created by the model logic and scheduled to start at a particular time and continue for the duration of the process; they are then either terminated or cycle through the process again. There may be several processes of the same type active at the same time at different stages of elapsed time. Both the discrete events and the processes used in COSAGE are transparent to the model user, but the user must be aware of their functions to properly conduct the simulation.

g. Representative combat samples can be produced from COSAGE using skillful and ingenious construction of input files. COSAGE can be used to simulate:

(1) Most types of offensive and defensive operations.

(2) The operations of US, allied, joint, combined (excluding naval), and threat forces from the individual to a combined arms army.

(3) The effects of terrain, weather, and obscurants on combat operations

(4) The movement of combat and combat support (CS) units on the battlefield.

(5) The performance and effects of most current and future weapons and equipment.

(6) The major aspects of target acquisition such as ground surveillance radars (GSR), forward observers (FO), flash and sound sensors, countermortar (CM) and counterbattery (CB) radars, and remotely piloted vehicles (RPV).

(7) The direct fire battle effects due to small arms, tanks, fighting vehicles, antitank guided missiles (ATGM), and mines.

(8) The indirect fire effects from tube artillery, mortars, and multiple launch rockets--to include the effects from conventional and improved conventional munitions (ICM), precision guided munitions (PGM), laser guided munitions (LGM) and mines.

2-2. PURPOSE. The primary purpose of the COSAGE Model is to realistically simulate a period (normally 48 hours) of conventional combat between Blue and Red forces to represent a tactical operation in some future conflict. This combat simulation has three objectives: to calculate expected ammunition expenditures, and equipment and personnel losses for both sides; to provide a record of killer/victim relationships to the ATCAL for calibration and use in theater models; and to provide a record of losses and expenditures to the simulation postprocessors.

2-3. STRUCTURE. The COSAGE Model consists of over 270 processes, events, and routines. The major components of the model are as follows:

a. Preamble - the preamble defines the internal data structure of the model and unifies all of the various components. The model can be thought of as a collection of data representing units, weapons effects, orders, etc. Functions such as unit position updates and equipment attrition can operate asynchronously on this data base. These functions can be independent in operation but they share the same common data.

b. Main - the main routine is the driver and, as such, causes the model to input the data and then perform the simulation by invoking the timing routines.

c. Input Routines - these routines input the model data and perform limited checking on the data, and initialize the model for execution.

d. Command and Control - these events, processes, and routines control the movement of units on the battlefield. They determine when a unit should change mission and when a unit should move. Direction control, movement rate, length of move, and termination of movement are other aspects of command and control that the model operates.

e. Small Unit Engagement - these events, processes, and routines control units while engaged in direct fire combat. They position the units in combat formations, cause them to close with the opposite side, and perform detections, engagements, and assessments.

f. Indirect Fire - these events, processes, and routines control all aspects of (indirect) fire mission planning, execution, and assessment.

g. Sensors - these events, processes, and routines control the different types of sensors, such as forward observers and radars, in their searches for opposing target units. Each sensor behaves differently according to the input data and model logic, but the objective of each individual sensor is to generate target reports which are forwarded to an appropriate fire direction center for processing by the indirect fire component of the program.

h. Output Routines - these routines print the results of the simulation to allow analyses to be performed.

Section II. SIMULATION PROCESS

2-4. DIVISION SIMULATION CONCEPTS

a. COSAGE attempts to simulate what will occur on a division battlefield. Tactical concepts and technical data are integrated throughout the data to accomplish this end. To realistically and faithfully portray combat, the tactical analysts must make use of the best data available.

b. Force information must be collected for the US, allied, and threat forces that will be included in the conflict simulations. This includes: organizational structures, personnel strengths and equipment availability, weapons types, densities, and characteristics, and types and quantities of munitions and technical characteristics. Additionally, information on tactics and doctrine must be researched to permit simulation of combat operations.

c. This basic information is preprocessed, checked for quality and completeness, and entered into computer files to be used by COSAGE, various theater models, and the postprocessors.

d. Based upon the study directive as provided by the proponent, expected division combat operations are portrayed. These operations are modeled and simulated using the COSAGE Model.

e. The COSAGE simulation produces sample performance data for a friendly (or Blue) division engaged during 2 days (48 hours) of combat for each of several types of combat operations modeled. The division may be a US division or an allied division. The appropriate size opposing (or threat) force is modeled for each simulated tactical operation.

f. Generally, six different combat operations are modeled for a study using one or more of the types of terrain described in Table 1-1.

(1) The Blue division in a prepared defense against an attacking Red force--Blue Intense Defense (I).

(2) The Blue division conducting a delay or a defense on alternate or successive defense positions against an attacking Red force--Blue Delay (D).

(3) The Blue division in a hasty defense against an attacking Red force--Blue Hasty Defense (H).

(4) The Blue division and a Red force are at parity and are both in defensive positions. Both sides are conducting patrols, probes, and reconnaissance--Static (L).

(5) Multiple Blue divisions conducting an attack against a Red division in a prepared defense--Blue Attack (F).

(6) Multiple Blue divisions conducting an attack against a Red division in a hasty defense--Red Hasty Defense (N).

Table 2-1. Terrain Types

Terrain type	Description	Examples
A	Flat to gently rolling with minimum obstacles and vegetation--excellent cross-country mobility for tracked and wheeled vehicles	North German Plain Desert plateau - Iran or Iraq
B	Gently rolling terrain with some obstacles and vegetation--good cross-country mobility for tracked vehicles and marginal mobility for wheeled vehicles	Central Germany Foothills - Korea and Iran Chorwon Valley - Korea
C	Mountainous with steep slopes and/or desne forestation or swamps. Poor cross-country mobility. Vehicles must remain on roads and trails	Southern Germany - Black Forest Mountains - Korea

g. Other combat operations (e.g., meeting engagement, Red delay, etc.) may be modeled as necessary.

h. The results of the division combat simulations are called combat samples. Combat samples represent the expected results, during a theater campaign, for division combat for 48 hours of the posture simulated. The combat sample is not intended to represent the first high-intensity period nor the last period when intensity is expected to be low.

i. Combat samples are analyzed to ensure that the military aspects of combat are adequately and faithfully portrayed in the model. The ammunition expenditures and equipment losses for both the Red and Blue forces are determined, and killer/victim (K/V) relationships are established.

j. The COSAGE results are converted to a 12-hour period for use as input to the Attrition Calibration (ATCAL) process. This calibrated data is then used in various theater models.

2-5. ATTRITION CALIBRATION (ATCAL)

a. The ATCAL process is a two-phase methodology. The calibration phase uses the COSAGE results from the combat samples to set calibration parameters for theater models. This calibration phase, in essence, sets the theater model to initial conditions. ATCAL Phase II is essentially a theater model subroutine which extrapolates for changes in force ratio, force composition, and force frontage.

b. The running phase of ATCAL (Phase II) adjusts the initial calibration parameters to account for new force mixes that result from attrition and replacements during the theater war.

c. To provide the necessary linkage between the COSAGE output and the ATCAL input, the Reduction ATCAL Linkage Phase I (RALPH) Program has been developed. This program reads the COSAGE output files, then modifies and aggregates output as specified in the RALPH system file to produce the information in a file format as required by ATCAL.

2-6. THEATER WAR SIMULATION

a. The theater conflict is simulated using the CEM, FORCEM, THUNDER, or TACWAR Models. These models simulate divisions in combat and the effects of tactical air across the theater front for the duration of the campaign. Decision and order logic is included for all echelons from theater to brigade level.

b. If there are several different scenarios being considered in a study, theater campaign simulations would be conducted for each of these scenarios. For example, campaign simulations employing high tech and low tech munition capabilities would be two separate scenarios.

c. The output from these theater models is analyzed, combined with basic system data, historical data, and combat sample results to provide the input for force sizing, force mix, capabilities analysis, and requirements briefings.

Section III. LIMITS AND ASSUMPTIONS

2-7. GENERAL

a. A computer model which simulates the combat of two armed forces typically experiences a software life cycle that includes growth by: adding new features and enhancements; improving existing features; improving operability and maintenance; and implementation of new computer hardware. The COSAGE Model was designed with a top-down, modular approach to facilitate the life cycle management (LCM) of the software. Real-world military procedures and tactics are represented with state-of-the-art techniques. Hence, a systematic approach to the model development resulted in prioritizing functional features and their implementation and incorporation into the model.

b. No computer model can simulate everything that happens in a division during a day of combat. Major combat functions are modeled and incorporated in priority of their effects on the battlefield. Some model limitations are dictated by computer storage capabilities, some are intangibles that cannot be modeled, and others are not modeled because they are not understood. Enhancements to the model are being made to incorporate some of the areas not previously included. Additionally, the analytical methodology imposes certain assumptions that are manifest in the design.

2-8. ASSUMPTIONS

a. Modeling a period of combat (generally 48 hours) produces combat sample results with sufficient interactions represented to be used as input to the theater model.

b. Two opposing sides or forces will produce combat sample results. Additionally, the synergistic effects of their close combat will be inherent in the combat samples themselves.

c. Tactical unit orders are articulated for the period of combat (48 hours) and represent the level of command and control of those units. Thus, a division is assumed to be in a posture for the period. Maneuver units process their orders throughout the simulation.

d. Blue forces are arrayed on the viewer's left in a graphical presentation, Red on the right.

e. Close combat occurs within the divisional battlefield as localized engagements or battles with different time durations and initiation times.

f. The Red and Blue task organizations do not change during simulations, except as a result of combat.

g. Mobility and firepower kills will not be repaired and returned to their units within the 48 hours.

h. The representation of terrain is by statistical data to the model; hence, combat in built-up areas, or special operations such as river crossings, are not explicitly modeled.

i. Logistics are sufficient for all units for the period (48 hours) of combat. The supply of ammunition is not limited except in cases such as fixed wing aircraft and helicopters, where supply is limited to the onboard load. Equipment such as tanks begin each battle with a full onboard basic load of ammunition.

j. Conventional warfare between two opponent forces is modeled. There is no provision for modeling the integrated battlefield; nuclear and chemical munitions are not employed by either force.

2-9. LIMITATIONS

a. The intangibles of combat--such as training level, leadership, morale, discipline, stress, and fear--are not modeled:

b. Combat is efficient in that units do not get lost; units do not fire at friendly forces; personnel do not fatigue and slow down; all personnel are well trained; and the units can continue to function effectively despite casualties.

c. Unit consolidation (the reorganization of combat ineffective units into an effective unit) is not modeled.

d. Personnel and equipment (material) replacement at the combat unit level is not modeled.

e. Maintenance (reliability, availability, and maintainability (RAM)) failures of direct fire combat equipment (tanks, antitank guided missiles (ATGMs), machineguns) are not modeled.

f. The intelligence function is not modeled; that is the gathering of information on the enemy force, assessing the information by volume and quality, and developing actions with the benefit of any such information is not a part of the methodology.

g. Communications between different modeled elements is perfect. The systems have an infinite capacity in handling the communication volume, and there are no misinterpretations or lost messages.

h. Electronic warfare or the overt attempt by one force to employ tactics or techniques to degrade the effective communications of the opponent force is not modeled.

i. Mounted troops (mechanized infantry) are not modeled in a subsequent dismounted (deployed for fire and maneuver) status. This status influences vulnerability to direct and indirect fires as well as movement speed.

j. The battlefield is a homogeneous terrain without natural obstacles or barriers such as rivers, mountains, forests, and buildings.

k. For indirect fire support, there are no harassment fire effects, no smoke drift due to wind, and no time delays for artillery or mortar adjustment.

l. Helicopters support only one battle per mission.

m. The forward line of own troops (FLOT) is continuous within the division area. The FLOT is divided into a number of sectors as specified in the System File. Within each of these sectors, the FLOT is defined by the forwardmost friendly unit.

n. The following special operations and techniques are not portrayed: reverse slope defense, military operations in built-up areas (MOBA), mine clearing operations, reconnaissance by fire, and A-10 hunter-killer teams.

o. Logistic activity such as the resupply of units with ammunition and petroleum, oils, and lubricants (POL) is not modeled.

CHAPTER 3

COSAGE METHODOLOGY

Section I. GENERAL

3-1. HOW THE MODEL PERFORMS

a. The COSAGE Model is basically a collection of discrete events and processes of different types supported by the relationships of modeled military operations. The input describes the units, equipment, weapons, and the parameters that depict their performance and relationships to each other, and the ability of the weapon to inflict a hit (kill) on an item of equipment.

b. The modeling approach requires that the battlefield be viewed in the context of systems and subsystems. The systems and subsystems are further grouped according to analytical compatibility by sets, groups, categories, and other partitions. The methodology in the development of COSAGE incorporates a classification of systems.

3-2. ORGANIZATION OF UNITS

a. The methodology to type, categorize, and group the modeled military organizations allows for the use of common features or attributes in the modeling process and configurations for the development of the computer program. This methodology gives the model flexibility and the inherent capability to drive scenario changes with data. By changing input data, the user can create and subsequently model any organizational structure.

b. A unit is the basic modeled military entity. A unit is defined by data descriptors that give it quantities of personnel and equipment. The resolution is the refinement given to military unit descriptors. The methodology calls for Blue and Red unit resolution to be platoon and company, respectively. A unit may operate singly or be part of an order of battle or military hierarchy and assume a role as a subordinate unit or a headquarters unit based upon the structure defined via input.

c. Every unit modeled is a type of unit, such as a tank platoon or an artillery battery. Generally, a type of unit equates to one of the US Army units or an opponent unit, organized under a specific table of organization and equipment (TOE).

d. The types of units are further grouped into categories of units. This definition provides for grouping of type units by some common traits of behavior patterns imposed by training or doctrine. Some traits may be their method of employment which causes them to be located generally within a given distance from the FLOT, or near a unit or set of units. These traits enable analysts to make certain assumptions or predictions about their detectability and/or vulnerability in modeling.

e. The categories of types of units are further classified into a higher system level in COSAGE called a grouping. These groupings are mutually exclusive subsets of the unit set. The four groupings modeled are maneuver, artillery, support, and combat aviation. These groupings are modeled with certain traits:

(1) Maneuver units are the ground combat units (armor, infantry) and do move and engage the enemy in direct fire engagements or battles. Maneuver units are vulnerable to detection by sensors of different types: direct and indirect. Maneuver units, when drawn into battle, are not only identified as a force, but also as a combat team. Such a combat or combined arms team is identified by the predominant category of units, such as armor, mechanized infantry, etc. This team type drives the battlefield type selection for the maneuvering tactics to be employed.

(2) Artillery units move with less detail than do maneuver units. They do not engage in direct fire engagements but are vulnerable to detection by sensors of different types, and they are susceptible to indirect fires from an opponent.

(a) The artillery unit subset is further grouped to model artillery unit employment. The methodology establishes every unit, categorized as artillery, as a battery. The battery description includes those attributes normally described to these military units, such as a firing rate, equipment howitzer type, and a list or queue of fire missions. Each battery may have a battalion headquarters which may also serve as the fire direction center for controlling fire missions.

(b) Batteries are further grouped into sets called type batteries to classify the behavior and employment of these units. The battery types include the specific indirect fire weapon in the table of organization and equipment (TOE), such as 155mm howitzer or 152mm howitzer. The battery types also describe the maximum effective ranges, the sustained firing rate, the minimum number of howitzers for battery employment, the munitions available (HE, ICM, illumination, smoke, family of scatterable mines (FASCAM), etc.), mission preparation time, and many additional parameters.

(3) Support units are those normally described as headquarters, engineers, signal, maintenance, and ordnance. Support units do not move and do not engage other units. They may be engaged by indirect fires and are vulnerable to detection by sensors of different types.

(4) The combat aviation units are those which have attack helicopters and scout helicopters in some mix according to their unit TOE. They are a special class of the support group. They move as a forward area rearm and refuel point (FARRP) when composed as a unit. The unit is further broken down into teams, similar to platoons, for employment. As an attack helicopter team, they move to a battle area, deploy, acquire and engage targets, and may be attrited through enemy fire.

f. Another treatment of units lies outside the organizational aspect but is necessary in the realistic portrayal of terrain and detection. Any of the units may become acquired or visible because of line of sight to other enemy units. As such, a visible maneuver unit is then subject to direct fires from the opponent and vice versa.

3-3. EQUIPMENT/WEAPON SYSTEMS

a. The methodology to type and group equipment systems and their subsystems employed in military operations allows for the use of common features for certain analytical purposes and modeling logic.

b. The methodology enables users to develop any weapon/equipment system to match their analytical needs, be it a present system, a system in engineering design, or one conceptualized for the battlefield of the distant future.

c. The weapon is the basic modeled system (in most cases, a subsystem) in the simulation. Every weapon belongs to a host system, be it a combat soldier, a tank, or other mobile or immobile platform.

d. The weapons are further grouped by type weapon to distinguish their employment mode or role. For example, a .50 caliber machinegun may be placed upon a tank, an armored personnel carrier, or a ground mount. Based on supporting data, the role of the machinegun may be the same or different from that of other .50 caliber machineguns.

e. Each weapon has identified with it a sensor that provides the ability to acquire and support the engagement against opponent unit equipment. These direct fire sensors model, in varying degrees, the basic human visual and enhanced (aided) visual capabilities. These modeled capabilities are the eyes and ears of the weapon systems for direct fire engagements. The current methodology specifies three levels (types) of direct fire/weapon sensors. They are infrared (thermal), enhanced optical, and optical systems.

f. The host system or equipment is named by its usual military nomenclature (i.e., US M1A1 tank = UM1A1). An equipment has such features as a maximum speed and a probability of kill pointer.

g. The equipment is further grouped into equipment type in the methodology to benefit from similar characteristics, such as size and armor protection. These descriptors are the same (or analytically very close) in magnitude for many systems or type equipment groups such as tanks and armored personnel carriers. For example, this manner of aggregation provides a method for addressing lethal areas to artillery munitions.

h. Howitzers or artillery pieces are unique equipment, employed to support the modeling of indirect fire systems. They cannot engage in direct fire exchange. They behave according to the type of battery and the host battery or unit descriptors.

i. The composition of equipment and weapons into weapon systems to be employed on the battlefield occurs at the unit level. At this point, a link is created to match the table of organization and equipment with the equipment onhand and with weapons by quantity and criticality. This becomes the contents of the unit equipment list.

3-4. SENSOR SYSTEMS (INDIRECT FIRE)

a. Sensors are the eyes and ears of the modeled battlefield, and they are the method by which searching for the opponent's units occurs. During the conduct of a search, certain mathematical functions are used to stochastically model the detection of a target unit. The power of a sensor is described by the input data as is its performance enhancement and degradation during the course of a simulation. This approach and design methodology enables users to develop a sensor system to match specific analytical requirements. Generally, the capability of a sensor is unique

and the mathematical expressions that model a sensor's behavior must be encoded and implemented in the model. In this context, sensors are denoted as a model with general operating parameters described.

b. There are thee types of modeled sensors, each specifying a certain operating capability in terms of range and probability of acquiring opponent units. Their operation is generally invoked by an event or process discussed in the following paragraphs with each sensor employing different techniques to partition the search area by width and depth.

(1) The Model Counterfire Radar describes the features of counterbattery and countermortar radar systems on the battlefield. Its generic features are a sweep angle, maximum on or operating time, a minimum off time, and a search width.

(2) The Model Forward Observer describes those persons or equipment, located in units on the battlefield, that have a search rate, a laser designator capability, and search ranges.

(3) The Model Passive Detection Base describes sensors that respond to artillery flash (night) and sound.

d. The sensor types described above are linked to the units on the battlefield or to the force. There can be multiple copies of each sensor, as described by the user's input data. Each sensor generates target reports when a target detection is made as result of a search. The target reports are subsequently processed for indirect fire mission generation.

3-5. EVENTS

a. The COSAGE Model is a grouping of discrete events of different types. The timing mechanisms or routines exist as a part of the SIMSCRIPT II.5 program library. The timing routines are conceptualized as the model's clock, and it advances according to the embedded logic, calling into execution the discrete events at their appropriate time(s) during the simulation.

b. The following is a list of the 33 event types in the COSAGE Model. Events are brought into being by the logic and scheduled to occur at a computed future time in the simulation. At the time of occurrence of one event, another event of the same or different type may be created and scheduled, or another portion of the program may be called into execution. The computed future time of execution may be derived deterministically or stochastically through mathematical computations. Events exist in sets by each type, and a set may have hundreds of events scheduled, waiting for the appropriate time on the simulation clock to be brought into execution. If there are several events of the same or different types scheduled to occur at the same time, they are executed by rules of precedence implemented in the program.

(1) The Activate Attack (ACT.ATK) event is set into execution when two opposing units come into proximity.

(2) The Activate Defense (ACT.DEF) event is scheduled when a unit's order set calls for it to assume a defensive mission.

(3) The Activate Move to Coordinate (ACT.MOVCOR) event is scheduled when a maneuver unit's order set calls for it to move to a specific set of battlefield coordinates.

(4) The Activate Move a Distance (ACT.MOVDIS) event is scheduled when a maneuver unit's order set calls for it to move a distance from its present location.

(5) The Activate Reinforcements (ACT.REINF) event is scheduled when a maneuver unit in battle requests reinforcement, and a maneuver unit capable of reinforcing is located.

(6) The Air Defense Engagement (AD.ENGAGEMENT) event is scheduled when an aircraft flight path intersects an AD sensor fan.

(7) The Artillery Occupation (ARTY.OCCUPATION) event is scheduled when an indirect fire unit has reached its new position to signal that the battery is laid and ready to accept fire orders.

(8) The Battle Ended (BTL.ENDED) event is scheduled when one force has withdrawn from the battle and the opponents no longer engage.

(9) The Counterfire Radar Activation (CFR.ACTIVATION) event is scheduled by an artillery volley of either counterbattery or countermortar fire.

(10) The Counterfire Radar On (CFR.ON) event is scheduled by radar employment rules for the radars modeled within a force on the battlefield.

(11) The Counterfire Radar Off (CFR.OFF) event is scheduled by radar employment rules for the radars modeled within a force on the battlefield.

(12) The Counterfire Radar Operator (CFR.OPERATOR) event is scheduled by a counterfire radar detection and a target report may be generated.

(13) The Change Weather (CHANGE.WEATHER) event is scheduled by user input to change the prevailing battlefield visibility parameters.

(14) The Dequeue Old Sortie Queue (DQ.OLD.SORTIE.QUEUE) event is scheduled to decrement sorties from a previously established queue.

(15) The Engagement (ENGAGEMENT) event is scheduled during battles when opponent units have acquired one or the other and direct fires are to be directed toward the opponent.

(16) The Get Next Order (GET.NX.ORDER) event is scheduled by different stimulus to maneuver units, causing them to examine the order set and execute the next specified order.

(17) The Helicopter Depart Battle (HC.DEPART.BATTLE) event is scheduled to return an attack helicopter team at a battle location to its FARRP. The event may occur when the team has expended its allowable time in the battle area.

(18) The Helicopter Engagement (HELO.ENGAGEMENT) event is scheduled during battles when the attack team has acquired targets and will direct fires to the target.

(19) The Initiate Preplanned Close Air Support (INIT.PREPLAN.CAS) event is scheduled in accordance with user input to generate a preplanned CAS mission.

(20) The Move (MOVE) event is scheduled to move the maneuver units on the battlefield.

(21) The Passive Detection Base Activation (PDB.ACTIVATION) event is scheduled by every indirect (artillery) firing and sets the flash or sound sensing process into motion.

(22) The Passive Detection Base Operator (PDB.OPERATOR) event is scheduled by a passive detection base detection and may initiate a target report.

(23) The Send Team (SEND.TEAM) event is scheduled by a battle in which the priority of the battle is above the threshold to require attack helicopter support.

(24) The Start Artillery Movement (START.ARTY.MOVEMENT) event is scheduled when the firing battery's location needs to be advanced or moved to the rear in response to the FEBA movement. The event sets into motion the necessary actions to relocate the battery.

(25) The Start Battle (START.BATTLE) event is scheduled when opponent units are within the activation proximity. The event sets up the parameters to support the subsequent battle modeling. It is initiated by an Activate Attack event.

(26) The Start Move (START.MOVE) event is scheduled in response to a maneuver unit's order set in which case the activate move to coordinates or activate move a distance events schedule the start move event.

(27) The Stop Artillery Movement (STOP.ARTY.MOVEMENT) event is scheduled for indirect fire units by the start artillery move event.

(28) The Schedule Artillery Movement (SCHEDULE.ARTY.MOVEMENT) event is scheduled when an artillery or indirect firing unit requires movement in response to the FEBA movement. It initiates the Start Artillery Movement event.

(29) The Update Location (UPDATE.LOC) event is scheduled during maneuver unit movement on the battlefield. One update location event schedules another until the move is completed.

(30) The Change Light (CHANGE.LITE) event is scheduled by the user to switch from daytime to night combat parameters.

(31) The End Simulation (END.SIMULATION) event is scheduled by the user to conclude the simulation.

(32) The Position Report (POSITION.REPORT) event is scheduled by the user to gain unit location data periodically during the simulation.

(33) The Set Debug (SET.DEBUG) event is scheduled by the user to turn on or off programmer coded logic used in debugging the model. When turned on, special output is produced to assist in evaluating and detecting errors in data or the model logic. SET.DEBUG statements can be included in the same runstream that submits a COSAGE run for execution.

3-6. PROCESSES

a. The modeling of processes can be thought of as the execution of a series of events. However, the big difference between events and processes is that events occur instantaneously in time whereas a process requires a certain time to conclude.

b. The following is a list of the 16 process types in the COSAGE Model. Processes are created or brought into being by the model logic and scheduled to occur at a computed future time in the simulation. Once activated, a process remains for the duration of the computed period of time and then it is terminated. The time of initiation and the time of duration may be deterministically or stochastically computed through mathematical expressions. Processes exist

in sets, and a set may have any number of processes scheduled. There may be several processes of the same type active and in different amounts of elapsed time. If several processes are to be activated at the same moment, they are executed by rules of precedence implemented by the programmer. Processes contain logic that mathematically performs certain functions. This logic may initiate other processes or events.

(1) The Aircraft Attack Target (AC.ATK.TGT) process models multiple passes by one aircraft at a ground target unit. On each firing pass, the aircraft selects a target equipment (for direct fire), delivers ordnance, and returns to the starting point for the next pass. The aircraft may be detected and fired on by the target unit and/or a supporting AD unit.

(2) The Assessment (ASSESSMENT) process controls the logic to determine the results of direct fire engagements, and is initiated by the SHOOT.OUT Process.

(43 The Close Air Support Mission (CAS.MISSION) process models the flight of several aircraft from the friendly airfield to the target and return. During the flight, the aircraft may be detected and fired on by AD units.

(4) The Fire Mission (FIRE.MISSION) process controls the logic to place indirect fires against a target unit. It is initiated when a firing battery is assigned the fire order in Process TARGET.REPORT.

(5) The Forward Observer (FORWARD.OBSERVER) process controls the activities and logic for forward observers in each force's units. It is initiated at the start of the simulation, and it describes the observer's searches, detections, and subsequent target report generation.

(6) The Helicopter Arrive Battle (HC.ARRIVE.BATTLE) process controls the movement of the attack helicopters from their assigned FARRP to the battle area and their subsequent deployment. It is initiated by the event called Send Team.

(7) The Helicopter Return to FARRP (HC.RETURN.FARRAP) process controls the movement of the attack helicopter team from the battle area to the FARRP and back to battle area. If required, it is initiated by the event HC.DEPART.BATTLE.

(8) The Helicopter Fire Process (HELICOPTER.FIRE) controls the engagements and behavior of the attack helicopter team when deployed in the battle area. It is initiated by the helicopter target acquisition process and initiates the helicopter engagements and events.

(9) The Helicopter Target Acquisition Process (HEL.TARGET.ACQUISITION) controls the search and behavior of the attack helicopter team, to include any modeled scout helicopters. It is initiated by the Helicopter Arrive Battle process.

(10) The Mine Assessment (MINE.ASSESS) process controls the logic to determine the effects of a unit encountering an enemy minefield. It is initiated by a routine that controls minefield effects.

(11) The Shoot Out (SHOOT.OUT) process models the direct fire action between units in a battle. It activates assessments and is initiated by an engagement event.

(12) The Target Report (TARGET.REPORT) process models and performs the necessary accounting of detections passing through the system of fire planning, assignment of batteries, and execution of the fire mission. It is initiated by any one of the several sensors modeled.

(13) The Withdraw (WITH.DRAW) process models and controls the logic for the rearward movement of units engaged in battles. It may be initiated by logic that periodically checks the status of the forces in the battle.

Section II. COSAGE BATTLEFIELD

3-7. GENERAL. The battlefield is defined in the COSAGE Model by features derived from input data. The paragraphs in this section provide a brief description of these features that make up the "Battlefield." The features apply to both sides symmetrically, but some are subject to variations in input data for a force modeled on the battlefield.

3-8. BATTLEFIELD ORIENTATION

a. The COSAGE battlefield is described by input (SYS.INPUT) data and can be visualized as a simulated rectangular piece of terrain upon which the combat occurs. The dimensions are a user input. Typical values are in the range of 40 kilometers by 80 kilometers. Moving units that encounter the edge are stopped from continuing their movement. The actual size of the battlefield selected does not appreciably affect the memory requirements or time to operate the model, and, though untested, the user may describe a battlefield of any dimension.

b. The battlefield is oriented so that Blue units are located on the viewers left, Red units on the right. This typically places the long axis in the left-to-right direction.

c. The battlefield has a Cartesian coordinate system with the origin located at the lower left-hand corner. Only the first quadrant of the system is normally used (+x, +y values). The x-axis runs to the right, and the y runs vertically. In this system, positions are described with x and y coordinate pairs similar to the standard grid system used for military mapping. Figure 3-1 depicts a typical battlefield layout.

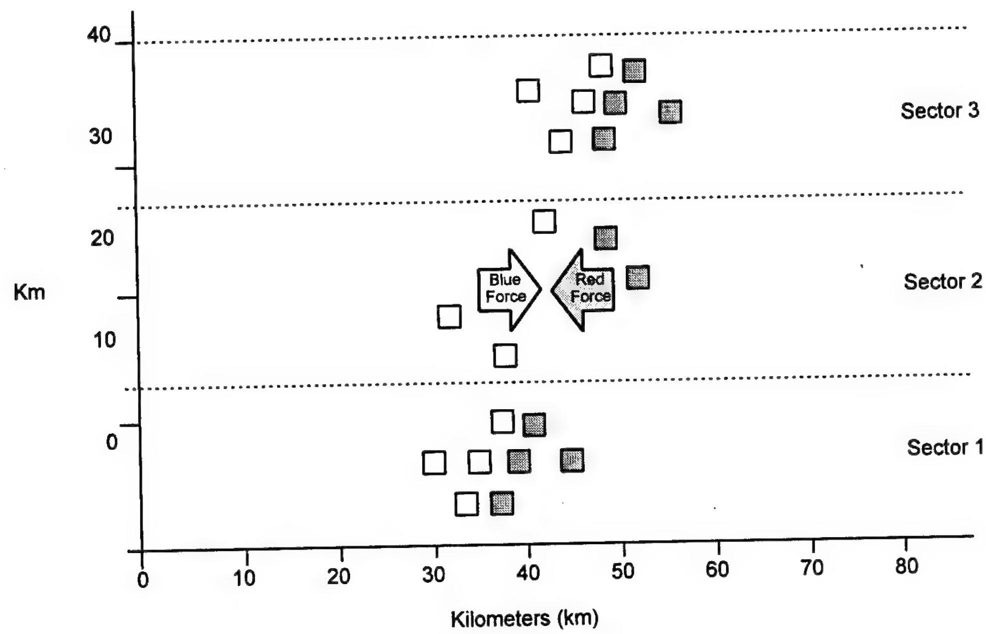

Figure 3-1. Battlefield Layout

d. True or magnetic north is not defined in the model, thus allowing the user to apply any force array. The battlefield may be oriented so that the COSAGE battlefield corresponds to the battle plan or array depicted on an actual military map. For the purposes of mathematical computations and logic test, the positive x-axis is the zero azimuth with a counterclockwise radial increase.

3-9. FORWARD LINE OF OWN TROOPS (FLOT)

a. The forward line of own troops (FLOT) is computed through the use of sectors. Sectors are lateral slices of the battlefield width and do not necessarily correspond to any military structure, such as a battalion sector, brigade sector, etc. The number of sectors is a user input. The location of the FLOT is defined and computed as the forwardmost unit of a side in the appropriate sector. A sector should contain at least a nominal number of units (four to five) from each side. The model initially divides the battlefield laterally so that all sectors are of equal width. The location of the FLOT, which is dynamic through the movement of units on both sides, influences other aspects of the model throughout the simulation.

b. Each category of unit (armor, infantry, support, headquarters, combat aviation) has a minimum FLOT attribute which is used in the target detection processes modeled. By this method, searches from different categories of units may be limited to those that are expected beyond a given distance from the FLOT.

c. An entity called Distance From FLOT Bands, or DFFB, is defined to support several processes. Each DFFB has a depth in kilometers from the FLOT location in a sector. The DFFB partitions give battlefield depth to a force. An analogy is the military concept of combat zones, but the DFFB does not dynamically follow the depth from the FLOT conventions in combat zone descriptions and it is not so intended. The DFFB apply to both sides modeled, and a typical number specified is five. The DFFB approach or methodology supports the following modeled activities.

(1) The employment of improved conventional munitions is based upon a (user input) usage indicator (yes or no) for the different categories of units located within the different DFFB.

(2) The maximum number of volleys of artillery fire that may be expended against a targeted unit is dependent on the target category, its DFFB, and the type of firing battery engaging the target unit.

(3) The maximum number of artillery batteries that may be massed to fire against a targeted unit is also a user input, based upon the DFFB and the unit's type.

d. Every type of indirect fire unit is employed within the model according to its normal indirect firing minimum and maximum effective range. Artillery unit location in relation to the FLOT is regulated by a (user input) minimum and maximum distance to the FLOT. Thus, artillery units by type which may be within their minimum distance due to FLOT movement are ordered to positions to the rear, and, conversely, artillery units found to be at their prescribed maximum distance from the FLOT during simulation are ordered to positions forward to maintain a proper distance to the FLOT, consistent with artillery employment doctrine.

3-10. TERRAIN

a. Terrain is modeled statistically. That is to say, the model may be set to randomly or deterministically select (based upon user input) the statistical parameters for terrain. Terrain features such as forests, urban areas, roads, and mountains must be incorporated into the

statistical parameters. The parameters are then used to determine line of sight, movement rates and other factors.

b. Terrain is defined through input data. Terrain types may be randomly or deterministically selected on the following occasions during the simulation:

(1) Opposing unit proximity tests are satisfied when units possess attack orders. The attack is initiated and the battle drawn. The type of terrain is selected and the terrain parameters are employed throughout the battle by both forces for line of sight (acquisition) and firing engagements.

(2) Artillery assessment is made against a targeted unit, and the battery effects are calculated based upon the type of terrain and the targeted unit.

(3) Precision guided munitions are to be employed against a targeted unit.

(4) When artillery or indirect fire unit movement is initiated, a terrain type is selected for movement rate computation. The computed rate is used for the entire movement.

(5) Unit movement is based upon sets of orders. As tactical maneuver units move, a type of terrain is employed to compute rates of movement.

(6) When unit environment is computed, the terrain type is selected and is a basis for computations.

d. The types of terrain are grouped for a regional scenario by terrain partitions. The three partitions currently used are:

(1) Partition A: Plains/desert (e.g., northern Germany/Mid-East).

(2) Partition B: Rolling hills/open terrain (e.g., Fulda, Germany).

(3) Partition C: Mountainous (e.g., northern South Korea).

e. The terrain partition used for a given simulation is a user input, and the specified group of terrain parameters becomes the set from which random selections are made. The user can specify a single nonrandom terrain type if so desired for a particular scenario.

f. The terrain type parameters include line of sight and nonline of sight shape and scale parameters for computations of a Weibull distribution. Also each terrain type has breakoff line of sight distance for stationary, moving, and moving-to-stationary units.

3-11. DAY OR NIGHT. The model recognizes the daytime and nighttime influence on combat through input data. The user, through system input (SYS.INPUT), selects the time at which "daytime" or "nighttime" is employed in computations. Generally, these times are derived from the scenario modeled and equate to the military beginning morning nautical twilight (BMNT) and early evening nautical twilight (EENT). The day or night periods influence such modeled activities as probabilities of detection, target location (circular error probable), probability of kill, smoke or illumination munitions employment, and movement rates.

3-12. ENVIRONMENT. In addition to terrain descriptors, an environment description is input for indirect fire (artillery) assessment computations. Typically, three environments are recognized: open, town (built-up areas), and woods. The user may describe any number of environments as long as they can be supported by lethality data. Units are categorized and each

category is defined as having a fractional percent of the unit's personnel and equipment in one of the defined environments. During the course of the simulation, a targeted unit's percent exposure in each environment is stochastically computed based upon type of terrain, movement status, and category.

3-13. POSTURE

a. Posture definition is related to combat troop behavior and relative individual protection which relates to vulnerability. Typically, three postures are modeled--standing, prone, and foxhole--and two types of individual protection--warned and unwarned. The posture data is employed for indirect fire (artillery) assessment computation. The user defines any number of postures, subject to data support.

b. The posture definitions are employed in the following modeled activities:

(1) Warned or unwarned personnel percentages of a unit by category, its mission and each posture influences the artillery assessment computations. Generally, the first artillery volley considers all personnel unwarned, and subsequent volleys and assessments are warned. All personnel, however, are assumed to be warned whenever ICM are employed.

(2) Lethality data for submunitions (of an improved conventional munition or ICM) is based upon a unit's environment and posture.

(3) The lethality (lethal area) of high-explosive (HE) munitions against personnel is based upon range, posture, environment, and fuzing.

3-14. MISSION

a. Mission definition is related to the decision criteria and support priorities modeled. Typically there are six missions modeled; they are:

(1) Patrol

(2) Probe

(3) Attack

(4) Delay

(5) Defend

(6) Ambush

b. The missions modeled apply to both sides or forces with different thresholds defined, via input data for each side. Decision criteria applies to the minimum percent of critical equipments a force's units must have to execute the particular (one of the six) mission. Another value based on the mission, by side, is a priority for obtaining attack helicopter support. The priority is a scalar value that is a relational user input. A third value based on unit mission is a minimum withdrawal range for maneuver units.

3-15. SMALL UNIT ENGAGEMENT BATTLEFIELD TYPES. This description should not be confused with the overall battlefield description. Through user input, several types of localized battles may be defined. There is also a generalized, or default, battle description which is generated dynamically by the model. Conceptually, these type-battles are templates used

throughout the simulation. Each type-battle is defined by Red and Blue missions, the total of Red and Blue units, and the number of armor, mechanized infantry, infantry, and headquarters units. During the course of the simulation when the opponent force maneuver sufficiently close enough to commence a (local) battle, the type-battlefield is checked for a fit. If there is a match, the localized battle follows the localized type-battle scenario. If not, then the default, generalized type-battle is employed.

3-16. SIDE OR FORCE

a. Each opponent is modeled as a side where side 1 is defined as Red and side 2 is Blue. Each side has attributes that influence the simulation; these attribute values are set by user input to model tactical doctrine represented within a study scenario. The features or attributes of each side are:

(1) A breakpoint is input for each side's units to define the percent of critical equipment that must be onhand at the unit in order that it be combat effective. As long as the unit's percent of assets is above this value, it is employed as an asset to the force. Conversely, once broken via attrition (by any source), it ceases to contribute in any fashion and is removed from the game. The breakpoint is not related to mission or unit orders, and should not be confused with the decision criteria mentioned earlier (paragraph 3-14b).

(2) A cost criterion flag (1 = true, 2 = false) which affects artillery munition selection during the simulation. This allows the user to set artillery round cost as the primary consideration in selecting available munitions for target engagement. If the flag is set to TRUE, the least cost round is selected as opposed to a selection based on lethality.

(3) A minimum marginal effectiveness value for indirect fire computations is specified input for each side. This value is expressed as the minimum contribution toward target destruction required of an artillery volley before it will be fired, measured as the probability of kill of the principal type equipment of the target.

(4) A desired effectiveness value for indirect fire computations is specified for two cases: one is input for moving targets, and a second for stationary targets. These values impose a further probability of kill constraint which must be realized for fire planning to continue in either case.

b. Each side or force has sets of entities or items that are used to achieve side control over the below processes:

(1) Passive detection bases or sensor.

(2) Counterfire radar sites.

(3) Forward rearm and refuel points (FARRP).

c. Each sector on each side has a rear location defined as the rear-most unit in the sector. This definition facilitates target detection and search logic.

d. Each side has a smoke munition employment rule depending on the mission of the side and whether it is night or day.

e. Each side has an illumination munition employment rule depending on the mission of the force.

f. Each side has a minefield employment rule dependent upon the mission of the force.

3-17. BATTLES. In the course of the simulation, opposing units maneuver and close to join in battle. The initiation, duration, and number of opponent units in a battle are dynamic, and are covered in detail in the chapter on small unit engagements. The subset of a side's units joined in battle is treated as a task force for the duration of the battle.

3-18. THIRD DIMENSION; HEIGHT CONSIDERATIONS

a. The battlefield, as a system, does not explicitly model terrain relief or the atmosphere. The third dimension is modeled with those systems that attain an elevation or altitude.

b. Tactical aircraft operate in a flight profile that gives them different altitudes or elevation above the terrain. The terrain level is considered to be zero, analogous to mean sea level. The profiles of tactical aircraft are associated with the ranges, or slant range in the target attack process.

c. Attack helicopters are modeled in their battle deployment with an altitude status that influences their actions and employment. They may be masked (hidden), unmasked (exposed) or on the ground.

d. Unmanned aerial vehicles operate at an altitude or elevation above the terrain that enables target acquisition at a level of target identification.

3-19. LIMITATIONS AND ASSUMPTIONS

a. Searches or target sensing by some sensors is accomplished by sector; thus, the FLOT and sector rear definitions plus the sector width provide a bound for the detection algorithms. Also, the unit categories may have a minimum distance to the FLOT prescribed, which reduces the search area for target categories.

b. Artillery lethality data is described by different combinations of postures, environments, and/or mission. The level of definition given these battlefield descriptors must be supported by data.

c. The switch from daytime to nighttime combat, or vice versa, and the supporting data is without any transitory period of gradually decreasing or improving visibility conditions. Also, other natural phenomenon that are linked to these changes (haze, visible moisture, etc.) are not modeled.

d. Break points for determining combat unit effectiveness apply to all units and in all missions with no regard for intangible as well as other tangible aspects of combat.

e. Units can participate in only one local battle at a time, regardless of their proximity to another local battle.

3-20. ALGORITHMS

a. The user should consider the following relationships in the COSAGE battlefield.

b. The Activate Battle Range (ACT.BATTLE.RANGE) is the distance for proximity testing between opponents and is necessary to commence a local battle. All maneuver units of a side that satisfy the test, and their subordinate units are drawn into the battle force.

c. The reinforcement proximity distance (REIN.PROX) is for logic tests when an engaged unit is seeking reinforcement. It applies to both sides modeled. A maneuver unit, not engaged elsewhere, and within the prescribed distance may be ordered to provide the reinforcement, thus becoming drawn into the task force.

Section III. COMMAND, CONTROL, AND INTELLIGENCE

3-21. GENERAL

a. Command and control within the COSAGE methodology are those features, by data input, design, and logic, that influence the behavior of the modeled force's units. The force structure of a given side or force is represented first as units, then grouped into categories, and finally into groupings. The four unit groups are: maneuver, indirect fire, support, and combat aviation. The grouping that is the object of primary command and control is the maneuver unit. As with the other portions of the program, command and control apply to both sides symmetrically. The other groups of units, specifically indirect fire, artillery, and combat aviation, are controlled by user input and model logic to support maneuver units.

b. Communications within the methodology are perfect in the context that orders are given to those maneuver units which can exercise them, and they are executed without consideration of any other factors. Information gained from fires or acquisitions at the individual unit level are not passed or communicated elsewhere in the organizational structure.

c. Intelligence in the traditional sense is not gathered, assessed, and acted upon at any one focal point. The information is retained locally and is acted upon locally by the units in the model. Intelligence for indirect fires is an active function given that sensors, aerial and ground, provide target information.

d. The command, control, communications, and intelligence activities of the unit groups are described in general terms in the remaining paragraphs of this section.

3-22. MANEUVER UNITS

a. The maneuver units are defined by the user during data file creation. Generally, they are all of the armor units, infantry units, and mechanized infantry units that are modeled in the force. Only those units grouped as maneuver units may have orders created and input by the user.

b. Maneuver units have the capability to establish line of sight and are then able to acquire other units. Adjacent unit information is not passed to other maneuver units nor the hierarchy unless command structure so permits. Maneuver units have sets of orders which govern their behavior in the model. Orders created by the user cause the units to advance, attack, withdraw, defend, and delay. Maneuver units are tactical units normally involved in fire maneuver (armor, infantry, and mechanized infantry units).

c. Maneuver unit movement resolution exists at two levels. First, maneuver units operate on the battlefield under a set of orders which are executed at the prescribed times or from other stimuli. Second, once drawn into battle, the order set is ignored, and the units begin to maneuver according to a battle plan (see Chapter 5).

d. Units from either force not engaged in a battle, but within the activate battle range of a pair of battling opponents, cause a momentary interruption while they are incorporated into the organizational structure of the appropriate force and join the battle.

e. Input features which control maneuver unit movement are as follows:

(1) Maneuver Unit Critical Number. This value is the amount of items of equipment that this unit has onhand that have been designated as critical to the unit's combat effectiveness. Such items would be tanks, armored personnel carriers, etc. The quantity of critical equipment items is computed and continually checked against a maneuver unit's break point level. For example, if the maneuver unit lost two out of five tanks in a platoon but originally had five critical pieces of equipment, it would now be at 60 percent of its onhand strength. If the break level were set at 65 percent by the user, this platoon would be below the break level and would be declared combat ineffective and a withdraw order would be executed.

(2) Maneuver Unit Reinforcing Indicator. This is a yes (1) or no (0) flag that is set on data input for the maneuver unit indicating that it can or cannot reinforce another maneuver unit of the same force. Other tests must be passed in order for the reinforcement to occur. First, the reinforcing unit must be within the prescribed range from the requester. Second, the unit must not currently be engaged in a different battle.

(3) Maneuver Unit Identification. This is the link that every maneuver unit has to the basic force structure. It identifies the permanent entity, UNIT, which is represented by the temporary entity, MAN.UNIT.

(4) Maneuver Unit Task Force List. A maneuver unit may own a task force list consisting of subordinate units; or it may be a member of a higher unit's task force list. The task force list in this case defines the battle organization and the hierarchy of all the maneuver units of a given force.

(5) Maneuver Unit Orders Set. The maneuver unit orders set is analogous to the operation plan for a particular maneuver unit and its subordinates. The order set may contain as few as one order or as many as desired to govern the actions of the particular maneuver unit. Refer to the input data file developments section of this manual for specific instructions on orders for maneuver units. Orders are input in a structured fashion that dictate, for example, that if a unit has made an attack but cannot complete the attack, it then executes a new order which may be to withdraw, or it may be to defend, etc. The orders set that has been developed and is input for the highest unit in the order battle hierarchy is imposed upon the other members of that hierarchy. Orders that reside in each maneuver unit's orders set have the following features.

(a) An Order Type. The order types that are presently incorporated in the methodology are as follows:

1. ATK. The attack order is a precursor to a battle. It is initiated as an order when a unit is aggressively moving towards the opponent and it comes within the activate battle range. When the test is satisfied, the unit order list is checked and if there is an attack order on the unit order list then that order is then invoked and the battle is drawn.

2. DEF. Maneuver units that are withdrawing or holding a position may have a defend order. If certain logic tests are passed, this order may be selected, in which case, the maneuver unit and all of its subordinates are then stopped in place, and they defend that position.

3. MOVCOR. This order specifies that a maneuver unit is to execute a move at its rate for that type unit on that terrain to a new location which is specified as an X Y coordinate.

4. MOVDIS. This order directs a unit to move a specific distance from its present location parallel to X axis of the battlefield.

5. **REINF.** This order provides for this unit to reinforce other maneuver units that may require reinforcement. If a reinforcing order is not in the maneuver unit's order set, it will not be able to reinforce another unit.

6. **MOVREI.** This order is not created by the user at input or based on the maneuver units order set. It is dynamically generated by the model to execute a move of a reinforcing unit to the reinforced unit.

(b) Order Identification. This value is the computer-generated number which identifies the specific order that is attack, move distance, move to coordinates, etc., that is used.

(c) Order Sequence Number. This value is the user specified value of ranking that orders have within the maneuver unit's order set.

(d) The Attack Order. This order has two values input by the user, and these govern the actions of the maneuver unit for two cases. The first is a value input to specify which order out of the order list is to be executed in the event a successful attack is completed against an opponent. A successful attack is one where the enemy unit withdraws. For example, if the enemy unit is withdrawing, the next appropriate order for the attacker might be to execute an order to move a distance. A feature of an attack order that the user must also specify is the sequence number of the order to execute in the event that the attack is unsuccessful. In this case, a logical choice would be to go to a defend order. If the defend order was the third order in the sequence specified for the maneuver unit, the input value would be an integer 3.

(e) The defend order is given to the maneuver unit by the user specifying the following input values that describe the defend order.

1. **Reinforcing Threshold.** The user input value is the percent of critical equipment that the maneuver unit must have onhand in order for it to be accepted as a reinforcing unit to another maneuver unit. For example, if the reinforcing threshold is set at 80, or 80 percent, the maneuver unit must have 80 percent of its critical equipment onhand in order for it to be accepted as a reinforcing unit provided other criteria such as distance are met. Values less than this cause this reinforcing unit to be rejected. Reinforcing thresholds are not currently used.

2. **Enemy Disposition Option.** This is the sequence number of the order to be executed in event the maneuver unit's defend order is successfully executed, as evidenced by the attacking opponent unit's breaking off its attack and beginning to withdraw.

3. **Maneuver Unit's Own Disposition Option.** This value is the sequence number of the order to be executed in event the maneuver unit's defense is unsuccessful and it is forced to withdraw. The unit must then select a new order to execute. An example of such an order would be a move distance order which specifies that the maneuver unit should perhaps withdraw 1,000 meters.

4. **The Defensive Orders Mission.** The integer values for missions as specified by the user are as follows: Patrol = 1; Probe = 2; Attack = 3; Delay = 4; Defend = 5; Ambush = 6. In this case, the order mission may be set to the integer value 5 (defend), which coincides with the name of the order. This may appear to be redundant, but it is necessary in the modeling effort to set other values such as the unit's mission.

(f) The Move to Coordinates Order. This order is incorporated in a maneuver unit's orders set to cause movement to a specific point, either at a given time or as an adjunct to another order. It has the following characteristics that are set by the user in the input data.

1. **Maneuver Unit Destination X Coordinate.** This is the X coordinate value of the battlefield grid coordinates system to which the maneuver unit is to move. It can be in any direction from its present location.

2. **Maneuver Unit Destination Y Coordinate.** This is the Y coordinate value of the battlefield grid system. This value and the X value define the location to which the maneuver unit should move.

3. **Maneuver Unit Movement Mission.** This value is one of the six mission integer values that define the unit's mission during the course of its move.

4. **Maneuver Unit Type Move.** This value is one of two words to define the nature of the move--ADMIN for administrative move or TACTIC for tactical move. A third type of reinforcing move, REINF, is not currently used. If the move type is reinforcing or tactical, the rate of move is computed to be the type unit's movement speed as a function of day or nighttime factor and the terrain type factor. If the movement type is administrative, the movement speed is computed to be three times the value computed for a tactical or reinforcing move. Normally, the administrative move to coordinates order is employed with reserve units, those normally positioned in a division rear as they would be deployed and moved forward. The administrative move is normally not used with tactical units that are displaced or positioned forward in the battle zone.

5. **Threshold for Reinforcing.** The threshold value is the percent of a maneuver unit's critical equipment that must be onhand for that maneuver unit to join an existing battle. This value is used when a maneuver unit is executing a move to coordinates order and encounters a battle in progress and by virtue of the range criteria should be drawn into the battle.

6. **Next Order.** This is the next order in the sequence of the maneuver order set that should be executed by this particular maneuver unit when it arrives at its final destination. For example, this may be a defend order or a subsequent move to coordinates order.

7. **Maneuver Unit Next Order - Above.** This is the sequence number of the maneuver unit's order list that is to be executed in event that it exceeds the threshold for reinforcement previously discussed. Such an order might be an attack order.

(g) The Move Distance Order. This order establishes a direction and a distance of move without regard to the unit's present location. The following input values specify a move distance order.

1. **A Direction of Move.** Specify an advance by entering ADV or a withdrawal by WITHDR. The direction of move is either advance to the FLOT or withdraw away from the FLOT. All moves are made parallel to the X axis from the unit's present location.

2. **A Distance of Move.** This value is input by the user to specify the distance that the maneuver unit must move in execution of a move distance order. It can be any value specified by the user such as 5,000 meters, 8,000 meters, etc.

3. **Move Distance Order - Next.** This value is the sequence number (in the unit's order list) of the order to be used when the maneuver unit completes the move distance order.

4. **A Movement Type.** The user enters ADMIN for administrative moves or TACTIC for tactical moves. Normally, the tactical move is employed for units located forward, and an administrative move employed for those units located in reserve positions.

(h) A Move to Reinforce Order. This order is generated dynamically by the model in the execution and is developed when a unit engaged in close combat requires reinforcements.

f. Battle Command and Control Features. The following user input items influence various aspects of the command and control of maneuver units that are engaged in local battles.

(1) Mission Decision Criteria. The user specifies decision levels based upon the maneuver unit's critical equipment percent onhand that govern modeled activities. The decision criteria are based upon the mission and the maneuver unit's side.

(2) Breakpoint. The breakpoint for all units, but most important for maneuver units, is the threshold or percent of critical combat equipment the maneuver unit must have onhand in order to retain combat effectiveness. A maneuver unit that reaches the threshold or break level is considered combat ineffective. The model does not consider the remaining assets of an ineffective maneuver unit. The personnel and materiel are no longer capable of performing the intended mission.

(3) Illumination Employment Rule. The employment of illumination munitions is in support of battles only. Their use relates to maneuver units, and the rules set by the user as to the employment logic influences the capability of maneuver units to acquire and engage opponent units in periods of reduced visibility and darkness.

(4) Mine Employment Rule. The employment of mines and minefields within the model is governed by the user input rules for minefield placement. The mine use rule is based upon each side and each of the user defined missions.

(5) Smoke Utilization Rule. The employment of smoke munitions is in support of localized battles only. Smoke use rules are defined by the user for each side, each period of night or daytime, and each mission that has been defined by the user. The employment of smoke degrades visibility and target acquisition capability.

(6) Type Unit Movement Rate. Each of the types of units has a specified movement rate as input by the user for this type of unit in its normal combat deployment configuration. The movement rate is utilized in calculating the speed of maneuver units on the battlefield.

(7) Distance Withdrawal. The distance withdrawal value specifies the distance which a maneuver unit that is forced to withdraw will fall back. The distance withdrawal value applies to those maneuver units within a battle, and it applies to units of both sides.

(8) Distance to Attack. The distance to attack applies to maneuver units that are involved in small unit engagements or localized battles, and it is the distance the unit with an attack order will attempt to move forward. This value applies to maneuver units of both forces equally.

(9) Width of Unit. For the Red and Blue forces, user input specifies the width of a maneuver unit in a general battle. The width of the unit specifies side-to-side separation that will exist between two friendly units in the battle area. The value is necessary because, elsewhere in the model, units are treated as circles.

(10) Activate the Battle Range. This value is the range at which opponent units will initiate a battle. If two units are within this range and logic tests are satisfied, the battle will be drawn. This value applies to both sides. If the user selects a value that is too small, the battle may be drawn at the point that the units begin employing all weapons (long-range and short-

range). If the battle range is too far apart, the battle may be initiated with long-range weapons and be terminated before the forces get close enough to use short-range weapons. Recent research has also shown that because units in battle move slowly (tactical battle speed), long-range battles last longer than short-range battles.

(11) Attack Delay Period. This value is a user input that causes maneuver units to take time for reconstitution before resuming another attack. The value applies to maneuver units of both forces.

(12) Reinforcement Delay Time. This value is a delay in minutes that is imposed upon a maneuver unit that has been selected to reinforce another unit prior to its initiating the movement. This time is analogous to the amount of time required for a maneuver unit to prepare to move. It applies to maneuver units of both forces.

(13) Reinforcement Proximity. This value is the maximum distance that a maneuver unit may be from another unit requesting reinforcement in order that the unit be considered capable of moving to the requester's location and providing the support. This value applies to forces of both sides.

(14) Reinforcement Threshold. This value is the percent of critical equipment which must be onhand in order to be considered as a reinforcing unit for a unit requesting reinforcement.

g. Command and Control of Maneuver Units in Small Unit Engagements (Battles). The behavior, or command and control, of maneuver units once drawn into battle is handled through he use of type-battle. The type battles are a set of user input values that provide a scenario for different types of battle situations. The definition of different battle situations is an indirect method for the user to provide definitions of the maneuver unit formations and how the task organization will be employed when they are drawn into battle. The type battle input variables allow the user to prescribe the battle formations in terms of unit lateral separation and the offset distance or set back distance for the headquarters units. In this manner the user describes a set of scenarios or templates to which the drawn battle is compared for quantities of units and composition of the force in terms of armor, mechanized infantry or infantry units. If the logic test for a particular type battle or template is satisfied this organization and control is employed throughout battle. In the event none of the user described scenarios or templates are found to be satisfactory for the combination of Red and Blue units that are drawn into a particular battle, a coded generalized battle contained within the model is employed to control unit behavior for the duration of the battle. Additional details on this aspect on this maneuver unit command and control is contained in the chapter on small unit engagements.

3-23. INDIRECT FIRE ARTILLERY UNITS. Command and control of indirect fire units is established by user input values. These units receive intelligence information from sensors that may be located on the ground such as forward observers or radars, or in the air from remotely piloted vehicles. They act on this intelligence information to place indirect fire on the opponent units. In terms of maneuver ability these units behave according to model logic and user input data that govern their movement to either advance toward the FLOT or retreat from the FLOT. The control of artillery units in the employment of artillery is discussed more thoroughly in Chapter 4. The descriptions that the user provides which define command and control for indirect firing units are as follows:

a. Battalion Assignment. The user defines the indirect fire unit organizational structure and the capability of a battalion by defining the number and types of batteries that are assigned to the battalion. These batteries can be of any stylized force mix consistent with the overall methodology and scenario.

b. The Number of Fire Missions that may Reside in a Firing Battery's Queue (firing list). The number of fire missions that can be on a firing battery list is limited to five. This forces the model to seek and locate other firing units that are within range and are capable of placing fire on a targeted unit. Without this constraint, a few firing units would receive the bulk of the fire missions.

c. Military Worth (threat) Threshold. These user-specified values dictate the various levels at which action will be taken on a proposed fire mission or target report based upon the military worth of the targeted (opponent) unit. These threshold values result in prioritization of missions consistent with employment doctrine.

d. Minimum and Maximum Battery Employment Distances. Each type of battery has a minimum and maximum distance that it may be positioned from the FLOT. These values are input by the user and control the ranges at which firing units will be positioned from the FLOT. The control of artillery units in this manner must be consistent with artillery employment doctrine because artillery units located well forward may be able to engage more targets at a greater depth, but will be subject to increased detection and engagement by the enemy force.

e. Minimum and Maximum Preparation Time. The user controls the firing capability of each type of firing battery by establishing the fire mission minimum and maximum preparation times. The behavior of the batteries is controlled by these preparation times which impact upon their ability to fire scheduled missions.

f. Time Between Indirect Fire (artillery) Movements. This value is a user-specified time (fraction of an hour) in which the artillery battalions are checked to establish whether or not any of the batteries in that battalion require movement to comply with the previously established minimum and maximum distance from the FLOT criteria. The frequency at which these checks are made may impose delays on artillery movements and should be considered in light of potential FLOT movement. A fast moving FLOT could place a battery in a vulnerable position, and if the check for movement is not made frequently enough, its vulnerability could greatly increase.

g. The CDI Usage Indicator. The user establishes through data input a flag (yes or no) that determines whether or not improved conventional munitions will be employed on a given category of targets in each distance from FLOT band. This value governs whether or not units of a given category, such as attack helicopter, mechanized infantry, armor, support maintenance, etc., will be subject to improved conventional munitions.

h. The Maximum Volleys of Fire. The user inputs a maximum number of volleys that will be fired against a target by a type of battery. This value is specified for each category of unit, distance from the FLOT band, and type of battery. This places a ceiling on the number of volleys that will be fired regardless of the effect.

i. Maximum Batteries on Massing of Fires. The user controls the number of batteries that will be drawn on a fire mission (massing of fires) against each type of unit (mechanized infantry, armor, etc.) in each distance from FLOT band. This value controls the number of batteries that can be massed to achieve the necessary level of coverage on a target.

j. Fire Direction Center Hierarchy. Through user inputs, a fire direction center hierarchy is specified. The specification of such a hierarchy provides control of the battalions that belong to fire direction centers and thus control the batteries. This hierarchy specifies the limits to which fire missions can be submitted up through channels for massing of fires and for such items

as precision guided munitions. The specification of the hierarchy for fire direction centers controls the processing of target reports and subsequent fire missions.

k. Target Report Abort Time. This is the amount of time, set by user input, that a target report remains valid. Failure to execute (at the battery level) a fire mission, prior to its abort time will result in the mission's being scrubbed.

l. Categories of Unit's Minimum FLOT Distance. The user specifies different categories of units through data input and subsequently establishes the minimum distance this category of unit is typically located from the FLOT. This information is in support of the logic for sensors and target acquisition processes. This information is manifested in target reports and subsequent fire missions performed by indirect firing units.

3-24. COMBAT AVIATION UNITS. The command and control features of combat aviation or attack helicopter units are driven by user inputs. The attack helicopter units may be deployed as teams or platoons from forward area rearm and refuel points where they advance to the battle area and join the battle. Other aspects of attack and scout helicopter employment are established by the type unit and type equipment connections. Certain parameters which influence attack helicopter employment are as follows.

a. Helicopter Battlefield Support Priority. When the battle is drawn between two opposing forces, a helicopter support priority for each force is computed for that battle. The value then is utilized in logic to select the battle that has the greatest need or highest priority for helicopter support given a choice among several battles ongoing at the same time.

b. Minimum and Maximum Target Handoff Time. The user, through data input, specifies for each force the minimum and maximum time for time delays involved in the scout's handing off a target report to an attack helicopter for subsequent engagement. The values apply to all helicopter attack teams of a side regardless of other operating characteristics.

c. Minimum and Maximum Masked Time. The user specifies the minimum and maximum times that the attack or scout helicopters are hidden. The actual masked time is a random variable uniformly distributed between these extremes. This amount of time influences the detectability of attack helicopters and their vulnerability.

d. Minimum and Maximum Unmasked Time. The user specifies the minimum amount of time that members of the attack helicopter team (scout or attack) may be exposed or unmasked for searching or for engaging targets. The minimum and maximum times are the lower and upper ends of a uniform distribution from which a draw is made to establish the amount of time that the helicopter is exposed to opponent detection and engagement.

e. Minimum and Maximum Positioning Range. The user specifies a minimum and maximum range for attack helicopter employment. The minimum and maximum range are then employed to compute the range at which the helicopter team will be deployed from the center of mass of the opposing task force in the battle. The minimum and maximum range form the lower and upper bounds of a uniform distribution from which a draw is made to compute the range that they will be positioned in battle. This can also be viewed as a so-called "standoff" range.

3-25. SUPPORT UNITS. The units that do not fall into the groupings for maneuver units, indirect fire units, or attack helicopter units belong to the grouping called support. The support units can range from logistics support units such as POL, ammunition points, direct support maintenance, general support maintenance, headquarters support units, and headquarters units. These units receive no intelligence information, nor do they have in the present model logic any command and control features. They are modeled as units in a static location with assets in the

form of equipment and personnel. These units may suffer the consequences of indirect fires, but they do not move, nor do they engage other units.

3-26. COMMAND HIERARCHY. Any maneuver unit in COSAGE can own a set of subordinate units. In this manner it is possible to create a chain of command. This hierarchy is not required, but its purpose is to allow the user to input orders to a headquarters unit such as a battalion headquarters, and have the subordinate companies follow the same orders. It is possible in this example to further break the companies into platoons, and by giving orders to one unit (the battalion headquarters), have the companies and platoons all follow the same orders.

3-27. LIMITATIONS AND ASSUMPTIONS. The methodology incorporates the following limitations and assumptions in the model logic.

a. Command or control is not influenced by an intelligence function. The gathering of intelligence and communicating it to a headquarters for evaluation is not modeled.

b. Communications during the simulation is not modeled; all necessary orders are established during model initialization.

c. Support units which include all types other than maneuver, artillery, and aviation do not move or otherwise function during the course of the simulation. They behave as potential targets for indirect fire.

CHAPTER 4

INDIRECT FIRE

Section I. GENERAL

4-1. FUNCTIONAL DESCRIPTION

a. The COSAGE Model features all of the components of artillery employment on the battlefield. Searches for opponent units are conducted through sensors, and detections are made which result in target reports. Target reports are processed for fire mission development and then may be forwarded to a fire direction center for assignment to a firing battery. When executed by a firing battery, an assessment of the fire volley is made against the target unit. Repeated volleys may be called for under certain rules of engagement. The model is dynamic in that fires are placed against opponent firing units, suppressing their ability to fire. Artillery fires are part of the battles or small unit engagements and cause those units in battle to suffer attrition, degrading their performance through the loss of personnel and weapon systems. The artillery units are vulnerable to the effect of their signatures (flash and sound), may be in turn detected by opponent counterfire radar elements as well as other sensors, and be attrited and suppressed through counterfires. Both sides share all of the modeled capabilities; however, the user, through the input data, describes the behavior of the systems for each side. The employment rules vary as to the type of munitions as well as type of battery.

b. The artillery or indirect fire weapons effects and the functional descriptions or mathematical descriptions of those effects necessitate several techniques in modeling. Those techniques are manifested in the COSAGE Model to the extent deemed necessary to portray the level of detail in assessment, consistent with the balance of the methodology.

c. Artillery unit behavior is dynamic in the context that a unit may be targeted and receive fire during the course of its attempts to fire. In so doing the unit has its performance degraded by imposition of delay as well as by the effects of the lethal area of the incoming munitions on the unit. As such the unit may suffer personnel casualties and materiel losses of its major items or any other represented item of equipment within the particular unit.

d. The following description provides the general and detailed model methodology. The reader should refer to the detailed discussion on input for the range of values normally employed, and sample data.

e. The reader should keep in mind that the descriptions are generally those employed in field artillery, but the modeling includes missile artillery, rocket systems, and mortars. Air defense artillery is not a part of this methodology.

4-2. ORGANIZATION DESCRIPTION

a. Indirect Fire Battalions. The indirect fire unit organizational structure is capped by a unit denoted as the battalion. The battalion is normally the headquarters and headquarters company TOE. Other intermediate levels of command such as a division artillery headquarters and headquarters company may be modeled, but the methodology identifies the battalion as the functioning level for firing battery control.

b. Fire Direction Centers. Fire direction centers are, in the real world, the place where target reports are analyzed, fire missions are generated, and missions are controlled in coordination with the overall force's mission and other units' missions. A modeled fire direction

center does not exist as a unit or have a TOE (materiel assets), but serves as a node or point in the fire control network for a given side (force). As such, it is transparent to the other battlefield processes and is not vulnerable to electronic warfare means or methods, or other loss-producing means.

c. Firing Unit or Battery. The level of resolution for indirect fire units has evolved as the lowest unit employment level consistent with each force's doctrine and training. This is not a hard and fast rule; the user may describe the firing unit to be of any size by creating a data file to support that definition. For COSAGE application, the battery is assumed to be analogous to the historical military definition. Example variations are: a field artillery battery can be described as six firing pieces all co-located; a battery of eight firing pieces can be describe as two batteries of four firing pieces each at two different locations, both served by the same FDC.

Section II. ORGANIZATIONAL DATA DESCRIPTIONS AND APPLICATIONS

4-3. MILITARY WORTH (THREAT)

a. Units are assigned priorities for engagement by indirect fire as follows:

(1) Every type of unit (may be equated to TOE) is assigned a scalar value (factor) by the user at the time of data development.

(2) This type unit factor is divided by a second, computed factor based upon the distance from the FLOT of the (type of) specific unit. The distance factor is computed as the inverse square root of the unit's distance from the FLOT.

(3) Units found at or near the FLOT have a high distance factor signifying a greater threat. Those well behind the FLOT have a low distance factor and represent a lower threat.

b. The scalar military worth factor generated by the user can range from 1 to 1,000. The military worth factor allows the user to direct the priority of fires to a type target unit. For example, by giving all 155mm howitzer type batteries a value of 950 and M1 tank type platoons a value of 1,000, the opponent's indirect firing priorities will be to engage front-line M1 tank platoons first, 155mm howitzer batteries second (assuming normal artillery employment), and rear, or reserve, M1 tank platoons third.

4-4. BATTALION FEATURES

a. Battalion Mission. This is a user input descriptor for data file creation, output file labeling and debugging. Typical values are GS (general support), GSR (general support reinforcing), and DS (direct support).

b. Battalion Unit. As with the batteries they control, a battalion is first of all a unit on the battlefield. This is required to support the model logic in linking the battalion to the type unit structure, and relevant data values for movement, assessment, etc.

c. Battery Set or Organization

(1) This set consists of those batteries assigned to the particular battalion headquarters, under battalion control. The user defines the organization through the data input by specifying which batteries are assigned. There is no limit on the quantity or types of batteries that may be placed under a battalion's control. This feature assists in creating a stylized force structure/array.

(2) The requirement to model different types of units, such as mortar sections or missile units, under the general field artillery descriptions dictates some departure from normal military concepts. For example mortars must be organized as a battalion though they are typically (real world) an organic platoon of an infantry unit.

d. Fire Direction Center (FDC). The battalion generally has a fire direction center as part of its organization. Each FDC has the following basic features:

(1) A Minimum (min) and Maximum (max) Fire Mission Processing Time. These min/max times are the lower and upper ends of a uniform distribution from which a random draw is made for the minutes necessary for the FDC to process the target report.

(2) A Current Target Report in Process. This value is set during the simulation and is a computer-generated number of the target report that has been removed from the FDC's target report list and is, at the moment, being processed.

(3) The Number of Target Reports Processed. This counter increments as a target report is processed at the FDC. It is for information only.

(4) A Target Report List or Queue. This list holds the target reports being sent to the FDC by the sensors (FOs, etc.). It is a list ranked by the target's estimated military worth so that the list is under continuous revision during the simulation, placing the reports in a high to low order. The highest valued target report is taken off the top of the list and processed sequentially by the FDC.

(5) A Completed Report List or Queue. This list holds the target reports that have been completely processed by the FDC. The processing may have resulted in a fire mission, or a cancellation due to target movement, low priority, etc.

(6) A List of Scheduled Missions. This list or queue holds those reports (FDC scheduled mission) that resulted in a planned fire mission at the FDC. The list is ranked by the computed start fire time at the battery(s), those with the earliest time at the top of the list.

(7) A List of Battalions. The FDC's list of battalions are those units the FDC controls in processing target reports and developing missions; if the FDC can process the mission, it is assigned to one of the batteries assigned to any one of the battalions that can meet the mission requirements.

e. Movement. Indirect firing unit movement is controlled at the battalion level. Three values are provided by the user that control the timing of the movement.

(1) Time Between Artillery Unit Movement. This value is the time lapse between checks of that battalions to see if any units require moving. It is provided in system input.

(2) Minimum/Maximum Distance to the FLOT. As previously mentioned, each type of battery has these two distances set by the user which are normally a function of the type battery's maximum effective range. During the periodic checks of the battalions, if any one of the batteries exceeds the minimum or maximum distance, the particular battery is given march order instructions to move in the appropriate direction to achieve the desired minimum or maximum distance. During the movement period, the battery cannot execute fire missions.

4-5. FIRING UNIT/BATTERY FEATURES

a. The individual batteries are grouped into sets by their common features or descriptions, referred to as TOEs. This formalization in the methodology of sets or types assists in reducing data and execution time and is analytically and doctrinally consistent.

b. The capability and performance of firing units are affected by model logic and input values. The data described below is included for each type firing unit.

(1) Battery Type. This value links the battery to a specific organizational, or TOE, set of values necessary for the unit employment. It offers additional descriptors to those mentioned as accessed by the unit-type unit link above.

(2) Battery Status. The status regulates the battery's availability to accept and execute fire missions. It must be occupying a position to accept and execute fire orders. The status codes used in the model are:

0 = Ready
1 = Occupying a position, but may not have batteries laid.
2 = Under march order instructions.
3 = Moving.

(3) Type Battery Name. The user normally applies the generic name such as "155HOW," "152HOW," "8INHOW," and others. This feature supports input data development, output file labeling, and debugging.

(4) Type Battery Howitzer Equipment Identification. This is the name of the howitzer. It must match a name entered in the equipment data.

(5) Type Battery Number of Howitzers. This value is set on input as the TOE quantity of firing pieces in the type unit; it is the basis for the number of howitzers placed into the individual battery's howitzer set.

(6) Type Battery Minimum Number of Howitzer. This value is set by user input and is the minimum quantity of available howitzers that must be at the battery for the battery to execute a fire mission. A battery can experience losses of howitzers or firing pieces.

(7) Precision Guided Munitions Capability. This value is set on data input as a flag (1 = yes, 2 = no) to identify those batteries having the capability to accept PGM or laser guided munition (LGM) fire missions.

(8) Type Battery Sustained Firing Rate. This rate is set by user input and is used to select available batteries for fire missions based upon the firing time periods in fire mission execution.

(9) Type Battery Maximum Range. The range is set by user input and is applied in selecting a battery to fire at a reported target.

(10) Type Battery Maximum Rocket Assisted Projectile (RAP) Range. The range is set by user input and is applied in selecting a battery to fire at a reported target that may be beyond standard munition range but less than the RAP range.

(11) Type Battery Suppression Time. This value is set by user input and applied during the selection and assignment of batteries to fire missions. If a battery has received incoming fire, regardless of the level of damage, this delay period is imposed.

(12) Type Battery Minimum Preparation Time. The value is set on user input and is the lower end of a uniform distribution from which a random draw is made to calculate the battery's mission preparation time. It does not apply to preplanned fires, and the drawn value is halved if the mission is in support of a maneuver unit.

(13) Type Battery Maximum Mission Preparation Time. This value is set on user input and is the high end of a uniform distribution from which a random draw is made to establish the particular battery's fire mission preparation time. It does not apply to preplanned fire, and the drawn value is halved if the mission under consideration is in support of a maneuver unit.

(14) Battery Fire Mission Schedule (list). As fire missions are generated by the target reporting process and processed through the FDCs, they are placed on the battery's schedule. The list composition changes throughout the simulation as missions are moved to the execution phase and placed on the fire mission queue.

(15) Battery Fire Mission Queue or List. This list holds the fire missions previously held on the schedule; this list is ranked by fire mission priority (highest to lowest). The list composition changes as the missions are executed or canceled.

(16) Current Fire Mission. This is the computer-generated number of the fire mission currently being processed (fired) by the battery.

(17) Type Battery Minimum Distance to the Forward Line of Own Troops (FLOT). This is a user calculated input value, generally a fraction of the type battery's maximum effective range consistent with the employment doctrine of the modeled force. It applies to the dynamic location of the FLOT in the sector in which a battery of this type is located. It is the stimulus for battery movement. If the FLOT moves to the point that the battery's distance to the FLOT is less than this value, a movement order is generated for the battery to reposition to the rear.

(18) Type Battery Maximum Distance to the FLOT. This is a user calculated input value, generally a fraction of the type battery's maximum effective range consistent with the employment doctrine of the modeled force. It applies to the battery and the dynamic location of the FLOT within the battery's sector. It is the stimulus for battery movement. If the FLOT moves to the point that the battery's distance to the FLOT is greater than this value, a movement order is generated for the battery to reposition forward. The object is to keep a firing battery in a favorable location to enable it to engage opponent units at a good depth in the enemy's rear and keep the battery out of detection ranges of the enemy counter battery radar.

(19) Type Battery March Order Time. This input value is the time, in minutes, required for a battery of this type to prepare for movement.

(20) Type Battery Occupation Time. The input value is the time, in minutes, required for a battery to occupy a new position and be prepared to commence firing.

(17) Type Battery Minimum Number of Minutes of Suppression due to Family of Scatterable Mine (FASCAM) Employment. This input value is the low value of a uniform distribution from which a draw is made to establish the suppression of fire missions imposed in the battery when it is the victim of a FASCAM mission.

(22) Type Battery Maximum Number of Minutes of Suppression due to FASCAM Employment. This input value is the high value of a uniform distribution from which a draw is made to establish the time suppression imposed on a battery that has been the recipient of FASCAM fires.

(23) Type Battery Maximum Number of Fire Missions. This is the limit on the number of missions that may be fired by a battery before changing its position to reduce its vulnerability to counterbattery fire.

(24) Type Battery - Type Munitions List. This is the list of munitions available to a battery of this type.

Section III. MUNITIONS

4-6. GENERAL

a. Munitions are assigned to batteries by the connection to a type battery (155mm howitzer, 105mm howitzer, etc.). Through the list of available munitions a selection is made by the rules of employment during the fire planning process and the selected munition is fired at a target. The batteries have only those munitions given by the user in the type battery input data. The initial goal during model development was to satisfy requirements issues. Therefore, there is no limit on the number of rounds fired. Rounds of various types are expended, records of their firing are made, and these become an output from the model.

b. Each munition (a specific caliber round) belongs to the appropriate class group. Thus the HE projectiles for the 81mm mortar, 105mm howitzer, etc., belong to the HE class group and are then linked to the type battery. The user should be aware that the input data that describes the effects of these different munitions is of paramount importance in the successful modeling of their employment.

c. The behavior of artillery munitions differs as to their purpose or classification. Employment purposes are to inflict casualties, damage or destroy equipment, delay unit movement, illuminate the battlefield at night, and obscure the battlefield during the day. Each of these purposes is achieved through different munitions each having different capabilities for assessment. The classifications are as follows:

- High explosive (HE) munitions.
- Improved conventional munitions (ICM).
- Smoke munitions.
- Illumination munitions.
- Family of scatterable mines (FASCAM) munitions.
- Precision guided munitions (PGM).
- Laser guided munitions (LGM).

4-7. HIGH EXPLOSIVE MUNITIONS

a. This class of munitions applies to calibers of projectiles. Each specific caliber is linked to the appropriate type battery through the user-developed munitions input data. Each HE projectile is described with the following:

(1) An Identification. This may be the projectile model, such as M107, M549, M106, XM650, etc. It serves for input data file development and output file labeling.

(2) Projectile Weight. This value is used in tallying the tonnage expended during the simulation and in round selection.

(3) Projectile Cost. This value, in dollars, may be employed in projectile selection logic to employ the least cost round as opposed to the most lethal round.

(4) Volley Radius of Effects. This value is based upon the lethal radius of one round fired per piece, given battery formation and firing sheaf. Formations may be line, lazy-w, diamond, star, and others. The sheaf may be open for soft targets and converged for hard targets.

(5) A Round Radius of Effects. The value is the lethal radius of one projectile fired from one piece.

b. Accuracy. The accuracy with which munitions are placed on a target of known location is fundamental to the assessment of damages. The methodology to address this accuracy error, or ballistics, applies the concept of range bands or range partitions to define the round accuracy over range. Each HE projectile or munition type is linked to each type battery through a set of range partitions (modeled as hacks or bands). Each HE projectile range band has the following accuracy information which is applied in the model.

(1) The range from a gun, howitzer, or mortar location is expressed in thirds for purposes of accuracy data. For example, a 15-km system is: first partition (band)--0 to 5,000 meters; second partition (band)--5,000 to 10,000 meters; third partition (band)--10,100 to 15,000 meters.

The last partition (hack) should be out to, and include, the maximum effective range of the type of artillery. The COSAGE Model requires definition of two range hacks, usually one-third maximum and maximum range. For RAP munitions and missiles, the current policy defines the two range hacks as one-third maximum range and maximum RAP range of the munition.

(2) A total or volley CEP for each of two input partitions (bands) described above. This CEP value is employed in computing the estimated coverage during the planning phase and the final coverage computed in the assessment phase. For ranges other than range hacks, CEPs are computed by interpolation between range hacks.

(3) A round CEP for each of two input range partitions (hacks). This CEP value is employed in computing the estimated coverage during the planning phase and the target final coverage in the assessment phase. CEPs are computed by interpolation for ranges between range hacks.

c. Fuzing. The capability to place different types of fuzing mechanisms on high explosive projectiles is modeled, including PD (point detonating) and, VT (variable timing) detonating. At present, the logic is structured for these two types; if other fuzing mechanisms were to be modeled, additional program changes would be necessary to support their modeling. The fuze methodology has these primary features:

(1) Fuze selection is dependent upon the percent of a target unit in the open. The rule is that if 50 percent or a greater amount of a target unit's personnel are in the open, the VT fuze is selected; otherwise, the PD fuze is employed.

(2) Each fuze on a munition has a reliability value input by the user in munitions input. The fuze reliability is utilized in computing the total number of rounds delivered on the target, and subsequently the total area covered.

d. Effects. The objective of HE employment is effective coverage of a target, producing damages or suppressing the capability of the targeted unit. The methodology incorporates the use of lethal areas to express the effectiveness of HE munitions. The lethal area value employed is the lethality per projectile. The methodology employs two types of lethal areas:

(1) Personnel. A lethal area for each of two range hacks against personnel for each projectile (or munition) is a function of the range (partition or band), the environment (open, town, or woods), the posture (standing, prone, or foxhole), and the fuze (PD or VT) employed.

(2) Equipment (materiel). A lethal area for each of two range hacks against equipment for each projectile (or munition) is a function of the range (partition or band), the type of equipment group the equipment belongs to (heavy armor, light armor, etc.), the environment (open, town, or woods), and the fuze (PD or VT) employed.

4-8. IMPROVED CONVENTIONAL MUNITIONS (ICM)

a. The ICM class of munitions applies to all calibers of indirect fire weapons. Each specific caliber projectile is linked to the appropriate type battery through the user's munitions input data. Each ICM projectile is described with the following.

(1) An Identification. This may be the projectile model, such as M444, M483A1, M404 etc., or other label that serves the user in input data file development, output file labeling, or debugging.

(2) A Projectile Weight. This value is used in summing the tonnage of munitions expended during the simulation and optionally for round selection.

(3) A Projectile Cost. This value, in dollars, may be employed in the projectile selection logic, wherein a least cost round may be selected over the most lethal round.

(4) A Projectile Reliability. This value is the probability that the munitions will arm when fired from the piece. It is used in the methodology in determining the number of rounds that detonate over the target area.

(5) A Battery Volley Radius of Effects. This value is based upon one round fired per piece in the battery, given a formation and firing sheath.

(6) A Submunition Index. This is a value that points to the specific submunition in the submunition input data.

(7) A Submunition Quantity. This is the number of submunitions (rounds) contained within the ICM projectile.

b. Accuracy. The accuracy with which munitions are placed on a target of known location is fundamental to the assessment of damages. The methodology to address the accuracy or ballistic error applies two concepts. They are as follows.

(1) ICM Submunition Dispersion. For each type of battery and each different type of ICM, the dispersion or pattern radius of the ICM is given by the following function of gun-to-target range:

$$\text{DISPERSION} = Y_O + M\ (\text{RANGE}),$$

where Y_O is the intercept and M is the slope, defined below:

DISPERSION is the radius, and RANGE is the gun-to-target range. The user specifies intercept and slope in munitions input.

(a) Intercept. The value is the intercept of the line that produces the radius of the circle of dispersion of the submunitions.

(b) Slope. The value is the slope of the line which yields the radius of the circle of dispersion of the submunitions overall gun-to-target ranges.

(2) Range. The concept of range partitions or range bands is applied to define the round accuracy over range. Each ICM munition is linked to each battery through a set of range partitions. Each range partition has the following accuracy information which is applied in the model. The user specifies these data in munitions input. The input data requires definition (in meters) of two range hacks, usually one-third maximum range and maximum range. For RAP munitions and for missiles, the current policy is to define the range hacks as one-third maximum range and maximum RAP range.

(a) A range from the firing piece.	For example:
First partition (band):	0 to 3,000 meters
Second partition (band):	3,000 to 7,000 meters
Third partition (band):	7,100 to 12,000 meters

(b) A total, or volley CEP, for each of two input range partitions. This CEP value is employed in computing the estimated coverage during the planning phase and final coverage computations in assessment. For ranges other than the range hacks, CEPs are computed by interpolation between range hacks.

(c) A round CEP for each of two input range partitions. This CEP value is used in computing the estimated coverage during the planning phase and the target coverage in the assessment phase. For ranges other than range hacks, CEPs are computed by interpolation between the two range hacks.

(3) Submunition Reliability. The destructive power of the ICM projectile is contained within individual submunitions or grenade type devices. The quantity and type within an ICM round was presented above. Additionally, each submunition type in each environment has a reliability value input by the user. This value is used as the probability of the submunition arriving and detonating correctly in the given environment--open, town, or woods.

(4) Improved Conventional Munitions Effects. As developed in the preceding discussion, the ICM effects are through the submunitions dispersing (ICM and scattering) and finally the detonation of the individual submunitions. The damaging or suppression effect of the ICM round is modeled through lethal area values. The lethal areas are defined for the two range hacks as input in the munitions data. The lethal area value employed is the lethality of each submunition. The methodology uses two types of lethal areas:

(a) Personnel. A lethal area against personnel for each submunition of an ICM round is a function of the environment (open, town, or woods) and the personnel posture (standing, prone, or foxhole).

(b) Equipment (materiel). A lethal area against equipment for each submunition of an ICM round is a function of the equipment's type (light vehicle, medium armor) and the equipment's environment (open, town, or woods).

(5) Employment. The methodology for ICM munitions employment differs from the other types of munitions modeled. The user has the capability, through rules of engagement input, to be elective as to the category of units (armor, field artillery, infantry, mechanized infantry, etc.) against which the ICM will be employed, and their respective (individual unit) distances from the FLOT. By indicating true (1) or false (0) in the specific input data, the model may or may not consider ICM employment against a target unit.

4-9. SMOKE MUNITIONS

a. The user may specify in type battery input which indirect fire weapons can fire smoke munitions. Additional information on smoke munitions is provided in Chapter 9. Each smoke munition employed has the following characteristics, specified by the user in smoke input.

(1) An Identification. This may be the projectile model, such as MM84, M60, M110, M116E1, etc., or other label that serves the user in input data development, output file labeling or debugging.

(2) Volley Width. Smoke width which could produced from a volley of munitions, a volley being one round fired from each piece of the firing battery.

(3) A Munition Burn Time. The time, in minutes, that the munition will provide obscuring smoke.

b. Limitations. The methodology incorporated in the model does not address delivery errors over range, nor does the methodology explicitly address round dispersion or the reliability of the munitions.

c. Effects. The effect of smoke munitions employed is to block line of sight in the battles between opponent units. The effects are deterministically computed based on the munition burn time. When line of sight is blocked, the ultimate effect is to remove opponents from line of sight and terminate direct fire engagements.

4-10. ILLUMINATION MUNITIONS

a. This class of munitions applies to all indirect fire weapons, subject to the user giving the capability to a type battery via the type battery-type munitions link. Each illumination munition modeled has the following characteristics.

(1) An Identification. This may be the projectile model, such as M314, M118, M335A1, etc., or other label that serves the user in input data development, output file labeling, or debugging.

(2) A Munition Illumination Radius. This is the radius of the area illuminated on the battlefield by a delivered volley of the munitions; a volley being one round fired from each piece of the firing battery.

(3) A Munition Maximum Range. The maximum range, from the firing battery, out to which the munition can be employed. This is a value less than or equal to the piece's maximum range.

(4) An Illumination Duration. The number of minutes that a round provides effective illumination on the battlefield.

b. Limitations. The methodology incorporated in the model does not address delivery errors over range, nor does it address round reliability or dispersion.

c. Effects. The effect of illumination munitions employment is to provide the line of sight between opponent units in a battle. The effects are set for each unit in the battle by selecting the line of sight data for daytime computations as opposed to using the night time parameters. Line of sight determination is made through stochastic processes. The result is increased detection of opponent units and increased direct fire engagements.

d. Employment. The methodology for the employment of illumination munition differs from the other types of indirect fire munitions. The user specifies rules for employment on input for each side and mission. The rules dictate the area to be illuminated as to friendly or enemy and degree of coverage. Illumination is requested only through the engagements resulting from battles.

4-11. FAMILY OF SCATTERABLE MINE MUNITIONS

a. This class of munitions is applied to those indirect fire weapons that have been given the capability by the user via the type battery - type munitions link. Each FASCAM munition has the following (input) characterUistics.

(1) An Identification. This may be the projectile model, such as M449A1 or M483A1, etc., which serves the input file development, output data file labeling and debugging.

(2) A Munitions Maximum Employment Range. The munition maximum range from the firing battery is defined as the munition's second range hack and is the maximum range that the munition may be employed up to the firing piece's maximum range.

b. Limitations. The methodology incorporated in the model does not address delivery errors over range, nor does the methodology explicitly address round dispersion and the reliability of the munitions.

c. Effects. The effects of FASCAM munitions employment are to impose a delay on those opponent units encountering the mine field area or to assess personnel and materiel losses against those units in the minefield.

d. Employment. The methodology for FASCAM differs from the employment features of other types of munitions as follows.

(1) The maximum number of FASCAM volleys to be fired against a target by either side (force) is a user input. In fire planning, the number of volleys required is computed followed by the selection of the minimum value of either the computed number of FASCAM volleys or the maximum number of permissible volleys for the category of target, distance from FLOT, and type battery firing. The latter value comes from the general artillery employment rules (user input).

(2) A minimum and maximum FASCAM employment range between opponent units (not the firing battery) is input to govern the employment for both sides (forces). If the range between the requesting unit and the proposed target unit is less than the minimum or exceeds the maximum range, a fire mission is not planned.

(3) A maximum number of volleys of FASCAM munitions that may be directed at an opponent withdrawing unit is set by the user. This value applies to both sides modeled.

(4) The maximum number of volleys of FASCAM munitions that may be directed at an opponent attacking unit is set by the user. The value applies to both sides (forces) modeled.

(5) FASCAM employment rules are input by the user for each side and mission.

4-12. SMART MUNITIONS. The world of artillery munitions as modeled in COSAGE is divided into two classes--smart and dumb. HE, ICM, smoke, illumination, and FASCAM munitions are all dumb. Smart munitions come in two flavors: precision guided munitions (PGM) and laser guided munitions (LGM). LGMs require that a laser designate the target equipment in order for the round to home in on it. PGMs, on the other hand, do not require a target designator. When a PGM round bursts over a target unit, it scatters several submunitions, each of which can independently find and home in on a target equipment provided it is close enough. As with other munitions, PGM and LGM are made available to artillery by listing them in the type battery and munitions list. However, the effects of LGM rounds and PGM submunitions are modeled via probabilities of kill, rather like direct fire weapons, instead of lethal areas as are used in modeling HE and ICM.

a. LGM. An LGM mission begins with a target report generated by a forward observer who can designate targets for the munition. The user specifies a forward observer's capability to designate LGM targets by entries in the forward observer data. The forward observer must have detected at least one equipment for which the LGM has a nonzero probability of kill. The target must remain within line of sight of the observer during mission preparation and flight of the round. Before the start of the fire mission, a test based on a random number is made to see if the weather is suitable for firing the munition. The user specifies the probability that the weather will be suitable. A battery capable of firing the munition and linked to the FDC served by the forward observer must also be within range of the target. Once a round of the munition is fired, the model assesses the effect of the round based on its probability of hit and the probability of kill given a hit. The probability of hit depends on the range from the designator (i.e., the forward observer) to the target and whether the target is moving or in defilade. The probability of kill given a hit depends on the equipment and whether the target is moving or in defilade. All of these probabilities are user inputs for each munition.

b. PGM. A PGM mission begins with a target report generated by a sensor. If the sensor is a forward observer, it must have been specified in the forward observer data as capable of calling for a mission using this round; but this test does not apply to other types of sensors. The forward observer must not be too close to the target for his own safety; the minimum range required is a user input. (Generally, with the munitions currently modeled, most PGM missions are generated by counterbattery sensors.) A sufficient number of eligible target equipments must have been detected within the target unit. The user specifies which types of equipment are eligible targets, and how many must be detected, in the PGM data. Eligibility may also vary depending on whether or not the unit is moving. A battery capable of firing the munition and linked to the FDC served by the sensor must also be within range of the target. After a PGM round is fired, the model simulates the bursting of the round, the scattering of its submunitions, and each submunition's search for a target equipment. The point at which the round bursts is random, based on the location of the target unit and the round's CEP. The submunitions are scattered randomly throughout the round's area of authority. Target equipments are viewed as scattered randomly within the target unit, and each submunition looks for eligible equipments within the submunition's footprint. If any targets are found, the submunition chooses one at random and attempts to kill it. The model decides whether the equipment is killed, making a random decision based on probability of kill data. The probability of kill depends on the type of equipment and the target unit environment (open or woods). The CEP, round area of authority, number of submunitions per round, submunition footprint, and probabilities of kill are all user inputs.

c. Smart Munition Priorities. When a sensor detects a target unit, it is possible that several smart munitions may be eligible for firing at it. In this case, the determination of which munition to fire is made based on the perceived type of target unit (not necessarily its actual type) and priority lists provided by the user. The user provides two lists of smart munitions for each type of unit, one to be used when the unit is stationary and another to be used when it is moving. The smart munition selected for firing will be the one of highest priority among the munitions eligible.

Section IV. INDIRECT FIRE SYSTEM METHODOLOGY

4-13. GENERAL

a. The purpose of this section is to bring together the elements previously discussed and present their relationships in an approach that gives the user the flow of the methodology.

b. The basic organizational features have been previously discussed; i.e., units, type units, batteries, type batteries, munitions, battalions and FDCs. The features to be discussed now are:

(1) Sensors

(2) Target reports

(3) Preplanned fires

(4) Fire missions

c. The methodology is applicable to both forces modeled, subject to the user's definition provided by data input. Associated data bases for indirect fire can be created with adequate detail and flexibility to portray the full range of indirect fire systems.

4-14. TARGETING

a. Targeting is initiated by a sensor in the course of conducting the searches of the battlefield, be it target of opportunity or within a battle. At the point that a unit's detection is made, information is placed into a target report as a result of the sensor's activity.

b. Sensors. The sensor methodology is complex and is discussed as a separate portion of the modeling methodology in other chapters. The sensors, be they the numerous forward observers (FO), passive detection bases (PDB), or counterbattery radars are the sources of information (intelligence) on the opponent. They produce the target reports which are the stimuli for the indirect fire system activities. The sensors must complete a target report for other indirect fire activities to commence.

c. Target Reports. The target report methodology is implemented as a process in the COSAGE Model. Though a target report in the real world may be viewed as an event in and of itself, the process approach serves several modeling needs; it comes into being, has actions performed on it, initiates other actions, and then ceases to exist. The target report has the following features, all of which are set during the course of the simulation. The total target report is completed over the passage of time by different sets of logic in the model.

(1) Once the unit is stochastically detected, the logic processes the detections of different types of individual equipment items. As they are detected, they are filed into the target report

detection list. A secondary operation performed on this list is to determine the quantity of equipment that can be targeted by smart munitions.

(2) The target report is prepared for action by the FDC to whom the detecting sensor must report.

(3) The sensor type is annotated to the target report for reference and bookkeeping.

(4) The sensor's computer-generated identification number is placed on the report for reference.

(5) The sensor's parent (host) unit identification is placed on the target report for reference.

(6) The target unit identification is placed on the target report for reference.

(7) The movement status of the target unit is set as moving (true) or stationary (false) on the report. If the target is moving, a secondary operation is performed to estimate the movement for inclusion into the target's estimated location.

(9) The target report's mission type is appended to the report. They may be one of the following:

- Smoke
- Illumination
- FASCAM
- HE or ICM
- PGM or LGM
- LGM

(10) The estimated X and Y location of the target is computed using the sensor's CEP value and any estimated movement parameters, and the estimated location is added to the report. For the following special munitions, estimated target location rules apply:

(a) Smoke - the detecting (requesting) unit's smoke use rule governs whether the smoke will be placed on the requestor's X and Y location or the target unit's X and Y location.

(b) Illumination - the detecting (requesting) unit's illumination rule governs whether the illumination rounds will be placed over the requestor's X and Y location or the target unit's X and Y location.

(c) FASCAM - the target units X and Y location is the estimated location.

(11) The estimated military worth of the detected target is added to the report. The value applied are:

(a) Target of opportunity (nonbattle)
Standard mission: 0
Smart munition mission: User input

(b) Maneuver support (battle)
Standard mission and
Smoke, illumination, FASCAM: 2000
Smart munition: User input

(12) A test is made to determine the sensor's status. If it has not been destroyed, a transmission time to communicate the target report to the FDC is computed as a random draw from a uniform distribution given specifying minimum and maximum transmission times, which are input in type sensor input. If the sensor has been destroyed, the target information gathered to his point is destroyed.

(13) The target report is activated for processing by the FDC with a report received time set at the current simulated clock time. A target report abort time is appended to the report. The abort time is a user input. As the report is subsequently reviewed, it will be canceled if it is not processed to execution prior to the abort time.

4-15. FIRE DIRECTION CENTER PROCESSING. Conceptually, the target report is processed at the FDC which was determined by the designated FDC. The processing at the FDC elapses over time with computed delays representing the activity within the FDC. A search is made to locate the battery or batteries, if massing of fires is required to provide the necessary target coverage. The following treatment is the general order in which the target report is processed. In many instances, target reports are repeated as follow-on missions. In this event, the same target report is used again by the FDC, thus eliminating a repeat of the preceding steps.

a. The target report mission type is evaluated, and if not set, is set to HE.ICM at this point.

b. A target analysis is performed through logic tests and statistical analysis of the opponent unit types. Given the sensor's list of detected items, an estimate of the type unit and an estimate of the unit size is made. The target report is annotated with the estimated type unit and the radius of the estimated type unit.

c. The estimated military worth is computed. If the military worth of the target has been previously set at 0, an estimated worth is computed and the value appended to the target report.

d. A check is made of the FDC's completed target report list, searching for a duplicate report. If a duplicate is found, the abort time of this report is set to a maximum value so that this report will be scrubbed at the next check point in the logic.

e. A check is made of the FDC's target report queue (list) to see if a duplicate report exists. If the comparison test locates a duplicate and if the sensor on the present report is not set, the reports will be consolidated. Then, unless the present report is a smoke, illumination, or FASCAM mission, it is removed from the processing and destroyed.

f. The target report is added to the FDC's target report queue.

g. The FDC's processing is checked to see if it has another report in progress; if so the present report is put in a hold status. If not, the FDC continues to process the present report.

h. The target report abort time is checked; if the abort time is past, the report is scrubbed from the FDC.

i. The target report is evaluated for suitability for smart muntions. If all tests are passed, a fire mission is generated.

j. If there is no battery/battalion to meet the smart munition requirements, the mission is converted to an HE or ICM mission and the target's military worth reevaluated. If the reevaluation is unsatisfactory, the target report is scrubbed from the FDC's work.

k. If the report is for a mission other than a smart munition, the FDC begins to perform detailed processing by first computing the required effects based on the side's employment factors (moving or stationary).

l. A check of the report's abort time is made against the clock, and, if the abort time has passed, the report is scrubbed from the FDC's workload.

m. The FDC sequentially works through each battalion assigned to the FDC until the required effects on the proposed target are met by battery assignments and fire mission generation.

n. If the FDC cannot mass sufficient fires on the target, the target report is forwarded to the next higher FDC for additional fire support.

o. The computations are cleaned up at the FDC by removing the target report from the queue and placing it in the completion list, where it is held until the batteries have concluded firing missions pertaining to this report. Once the missions are completed, the completed target report list is scrubbed of this particular report.

4-16. FIRING BATTALION PROCESSING. The processing of a target report at the FDC produces actions at the battalion/battery level at the points indicated in the discussion above. It is at this modeled level that the fire mission is initiated and subsequently carried out. The modeling logic follows two routes; one is for smart munitions, the second is for all other missions including HE, ICM smoke, illumination, and FASCAM.

a. Smart Munition Missions. Except for smoke, illumination, and FASCAM requests, all target reports are evaluated for their suitability to generate smart munition missions. If the attempt to generate a smart munition mission fails, an attempt is then made to generate an HE or ICM mission. The following processing is performed on a target report in evaluating its suitability for smart munitions:

(1) If the target sensor is a forward observer, the time the target will remain within line of sight of the sensor is computed, based on line of sight parameters for the terrain.

(2) A random number is drawn from a uniform (0,1) distribution, representing the suitability of the weather.

(3) Each artillery battery served by the FDC is examined as a candidate to fire a smart munition mission. In order to be eligible, the battery must be in place (not moving), must have enough personnel and guns to still be effective, and must not be suppressed due to counterbattery fire or FASCAM.

(4) Each smart munition available to the battery is examined for suitability. First, the battery must be within range of the target, based on the munition's maximum range. Second, the military worth attached to targets of the munition must exceed the military worth threshold for this type battery. (The military worth is a user input for the munition and does not depend on the type of target.) Third, if the target sensor is a forward observer, it must have been identified in the forward observer data as capable of generating missions for this munition. Third, sufficient eligible targets must have been detected for this munition to be used. The minimum number is one for LGM, but for PGM it is a user input. Fourth, for LGM, the random number drawn in

step (2) is compared with the probability of suitable weather for this munition; if the random number exceeds the probability, the weather is deemed unsuitable. Fifth, for PGM missions generated by a forward observer, the forward observer must be far enough from the target unit for his safety. Sixth, if the sensor is a remotely piloted vehicle and the munition is an LGM, the RPV must not already be busy loitering above another target. Seventh, for LGM, the sum of the mission prep time and round time of flight must not exceed the time the target will be within line of sight of the sensor.

(5) If several battery/munition combinations pass these tests, the choice of battery and munition is based on the smart munition priority list for the (perceived) type of target unit.

(6) If all tests were passed, a smart munition fire mission is generated and assigned to the chosen battery.

b. Other Mission - Battalion Location. The following is the methodology incorporated into the model logic in the general order in which the target report is processed for HE, ICM, smoke, illumination, or FASCAM requests for fire.

(1) The target's distance from the FLOT is checked and set for use in computations; the computations allow for special munitions. Should the test fail, however, an erroneous report may be suspected and the target report scrubbed from the processing at the FDC.

(2) A check is made of each battery of each of the battalions assigned to the FDC to determine which batteries can fire the mission. Each battery satisfying the tests is placed on a "can fire" list and ranked first by the battery having the least fire missions to fire, and then by the shortest range to the target (closer batteries have priority). The tests are:

(a) The battery must be in a position (not moving).

(b) The battery must have at least the minimum required number of howitzers available.

(c) The battery must not be suppressed by counterfires.

(d) The target's computed military worth must be greater that the battery's fire mission queue threshold.

(e) The battery must be available. This is a function of the fire missions it is currently processing and their duration.

(f) The range to the target from the battery is checked. If the range is greater than the battery's rocket assist projectile (RAP) range, it is rejected. If it is less than the RAP range, but greater than standard charge firing range, it is accepted with a RAP mission flag.

(3) For each battery fire mission developed, the following informaÛtion is placed on the fire mission (record).

(a) The fire mission battery.

(b) The fire mission queue size of the battery, for reference purposes.

(c) The fire mission priority, set to the computed target's estimated military worth.

(d) The fire mission range, set to the battery to target range. The target identification is placed on the mission.

(e) The fire mission's RAP flag, set to either RAP or non-RAP.

(4) The battalion processes each battery in its "can fire" list. In the course of processing each one of the batteries (which have been ranked), the battalion sequentially checks for the type of fire mission and computes the fire mission details, which are the estimated mission effects of the volley fired by the battery under consideration. As each battery undergoes the computation, its number of volleys and their effects are computed, decrementing the target report's remaining effects until those effects are less than or equal to 0. When the remaining effects are less than or equal to 0 the target effect requirements have been achieved, and any remaining batteries in the "can fire" list are cleaned off the list and released for other missions.

(a) Illumination munitions computations.

(b) Smoke munitions computations.

(c) FASCAM munitions computations.

(d) HE or ICM munitions computations.

(5) The program accesses logic that determines whether the mission will be for HE or for ICM munitions.

(6) At this point, the fire mission that has been generated is filed in the battery's scheduled fire missions list and is filed in the target report's fire mission reference list. Also, a processing time for the fire mission is computed based upon the fire direction center and its type, and the fire mission start time is computed based upon the previously set start time.

4-17. PREPLANNED FIRES

a. The methodology for treating preplanned fires requires that the user input specific target information and in so doing generate a target report which is then processed by the FDC. The FDC treats this target report as another target report without regard to the sensor initiation and continues to process it as it searches for batteries or battalions that can fire the mission. The features that are set by the user through an external event notice to the program are as follows:

(1) The FDC which is to process this target report is designated. A sensor type is designated to complete the logic and provide for computations.

(2) The target report reporting unit which is related to the sensor is designated.

(3) The target unit is set on the target report.

(4) The precision guided munition status of the target is set.

(5) The movement time or movement status of the target is set.

(6) The estimated X and Y coordinate location is set for the target.

(7) The target report received time is set as the current time the external target report is read in.

(8) The target report abort time which is subsequently used in evaluating the target report is set as the current time plus 15 minutes. In other words, this target report must be processed to execution within 15 minutes or it is scrubbed from the processing.

(9) For the purposes of evaluating the target, the detected equipments, the probability of detecting, and the quantities detected are input and set for the target report.

b. The treatment of the preplanned fires is in accordance with the features previously discussed at the FDC artillery battalion and battery, and a fire mission may be generated.

4-18. FIRE MISSIONS. The methodology for fire missions represents the handling of the fire mission at the firing unit or battery until it is completed or thrown out. A fire mission is initiated and is treated as a process in the methodology. At the point that the fire mission is completed and placed upon the battery's scheduled fire mission list, it is ranked by its computed firing time. The following actions and computations are performed as the fire mission is processed at the battery.

a. A preparation time is computed from a random draw off a uniform distribution which is set by user input for that type of battery's minimum and maximum preparation time.

b. If the sensor status places it in support of maneuver units, the preparation time for the fire mission is halved and the battery commences preparing for the fire mission.

c. For each computed volley based on the fire planning that was previously completed, the battery fires the volley at its designated time. The period of firing may be one of two times:

(1) If the fire mission is a smart munition mission, the firing time is a random number drawn between min and max limits specified by the user's input data.

(2) For any other type munition, the firing time is computed as the inverse of the battery's sustained firing rate for this type of battery, evaluated in minutes.

d. At the conclusion of the firing by the battery, the program methodology systematically selects the logic that evaluates the firing of the volley. The logic is set with the following:

(1) If the fire mission was with FASCAM, the effects computed are those of minefield employment.

(2) If the type munition was illumination, the effects for illumination of either friendly or opponent units is computed.

(3) If the munitions included smoke, then the effects of the smoke munitions employment are computed and the results are imposed upon the units involved (a movement delay).

(4) If the munitions type was HE, ICM or PGM, or SADARM, the methodology calls for battery effects to be computed. When battery effects are computed, an assessment is made against the target unit, with appropriate attrition of personnel and equipment. The assessment applies to all enemy units on the battlefield including those in battle and those enemy fire units which may be involved in firing missions.

e. Sensor activity such as forward observers or RPVs which may have been suspended to process the target report and subsequently generated fire mission may be resumed so that they can continue to perform their searches for the opponent units on the battlefield.

f. Upon conclusion of the fire mission, the fire mission is removed from the battery's firing list, and any records of the fire mission on the target report are cleaned up.

4-19. INDIRECT FIRE MISSION ASSESSMENT. The purpose of this paragraph is to present an overview of the methodology associated with the assessment of indirect fire munitions. The assessment methodology is based upon the type of munitions employed and the appropriate munition coverage. There are coverage methodologies for each of the munitions employed as previously discussed.

a. Munition Types: HE, ICM, Smart Munitions, or SADARM. Methodology for these munitions is basically the same, with the exception of the computation of the effects or coverage.

(1) The terrain on which the target unit resides is evaluated and the target unit's environment is evaluated, determining the percentage which is in the open woods, and/or built-up areas.

(2) An artillery assessment is initiated given the number of volleys, the target location, and type target.

(3) For the different munitions the methodology employs different techniques for computing the number of rounds delivered. High explosive munitions consider fuze reliability in determining the number of rounds that detonated on target. ICM munitions utilize the number of submunitions and the reliability of the round in computing the number of submunitions that successfully detonate on the target area. The laser guided munitions (COPPERHEAD) class simply uses the number of rounds fired, assuming the round reliability to be 100 percent. PGM evaluation simulates the scattering of submunitions and each submunition's search for a target. The munitions are systematically evaluated, and the percent of equipment or material damages is computed with fractional coverage.

(4) If the target unit in the fire mission is an artillery unit and if the munition fired is FASCAM, a suppression time is computed for the targeted unit, and a delay is imposed prior to it commencing or continuing any missions it may have.

b. Illumination Effects. The employment of illumination munitions uses a separate set of logic that considers the employment rule prior to considering the effects of the munitions. The employment rule may dictate that the illumination is placed over the requester, or it may dictate that it was employed over a target unit. In either case, logic is employed that evaluates the quantity of munitions and the effects on the battle. The effects are to improve line of sight between the requester unit and the target unit in which case the data for line of sight computations, times to detect are computed, and detections are made based upon day time parameters. The illumination munitions are only employed in local battles that occur within the battlefield.

c. Smoke Munition Effects. Employment of smoke munitions invokes a separate set of logic. The smoke coverage is determined by employment rules that have been previously input by the users and are invoked based upon the side requesting smoke. The smoke use rules dictate the location of smoke munitions when targeted, and the resulting effect is to produce obscuration, i.e., to reduce the line of sight capability of the requesting unit and the targeting unit. Smoke considers unit movement; such that if a unit is moving and encounters smoke, it is forced to halt. Line of sight blockage or obscuration is determined through logic computations. The result is the imposition of a delay in movement, or removal of units that were visible from the affected unit's line of sight list.

d. FASCAM Effects. This section of the methodology addresses the employment of the family of scatterable mines which are fired onto an opponent unit and are not utilized as a minefield in the barrier context. In this methodology, the logic for minefield effects is employed as it would be employed for manually or machine emplaced mines. In this set of logic, a computed delay is imposed upon the unit encountering the minefield, followed by attrition calculations based upon the input parameters stated by the user for different types of mines. Casualties are computed as losses of equipment (materiel items are computed in the logic) like the other portions of the methodology imposing attrition upon the target unit. The unit has its amount of equipment onhand decremented by the losses imposed.

4-20. LIMITATIONS AND ASSUMPTIONS. The implemented methodology for indirect fire or artillery weapon systems in the COSAGE Model has produced the following limitations and assumptions:

a. The maintenance of munitions at the battery site is not modeled. The absence of munitions at the battery site requires separate consideration be made for the assessment of that amount of munitions that may determined to be lost through either damage or inadvertent detonation at the battery. Such a sideline analysis would consider the quantity of artillery units that have been assessed and the degree of assessment.

b. Artillery unit movement is represented only so far as the displacement of the firing unit or battery from a present position to a new position, either in advancement or repositioning to the rear of its present position. Artillery units do not move laterally. All movements are parallel to the X axis on the battlefield coordinate system. Also, artillery unit movement considers three delays; first is the delay from the time the battery sees its movement instructions or march order instructions to the time it starts moving. The second delay is the amount of time required for the battery to move from its present position to the new position. This delay is a computed time based on rate and distance, and of the stochastically determined terrain type. The battery makes a jump from its present position to its new location without encountering the difficulties of cross-country movement over various types of terrain. During that period of time in which it is moving, it is not vulnerable to any other hazards on the battlefield, with the exception of minefields. The third delay is imposed from the time of arrival at the new position until the battery is ready to fire. This delay is the amount of time that would be necessary for the laying of firing pieces and establishment of their location.

d. The communication of target reports and the generation of fire missions, which includes the communication of the fire mission to the battery, is perfect in the context that the transmission of such information has not been misunderstood or misinterpreted and the accuracy has not been distorted. Likewise, the communications occur in a perfect manner in that they are precisely given and received without questions, without double checks of the information which would normally cause a time delay to be incurred. Also not modeled is the potential for overloading the communication system. In the model methodology, the capability to receive and assimilate the information is assumed to be perfect; there is no loss of information, and the capacity of the system is infinite.

e. The evaluation of threat or the employment of military worth is a practical method of addressing targets or fire mission priorities. The user must be aware of the context in which it is employed and the necessity for properly scaling the military worth or threat values.

4-22. ALGORITHMS. The algorithm employed for assessing HE and ICM effects is the SuperQuickie II algorithm, as described in 61 JTCG/ME-77-14, Programmable Calculation Manual for Evaluating Effectiveness of Non-Nuclear Surface-to-Surface Indirect Fire Weapons Against Area Targets.

CHAPTER 5

SENSORS

Section I. GROUND SENSORS

5-1. GENERAL

a. The model's sensors are the eyes and ears on the COSAGE battlefield. The sensors are the means by which information is gathered on the opponent force and is then acted upon for the purpose of indirect fire support within the model. Sensors support the direct fire engagement portion of the methodology to the extent that weapon system characteristics provide for (see weapon inputs). Each sensor behaves according to its own capability and its role, which necessitates separate and distinct capabilities represented in the program code as mathematical expressions describing this behavior. Each sensor type must therefore be described for its own environment and capabilities. The result of each sensor's operation within the methodology is the same, that is to produce a target report, which then may be acted upon by a fire direction center.

b. The methodology for the modeling of sensors adheres to a system hierarchy and the concept of modeling them as processes. They are initiated by battlefield events, create or cause other events to occur, and have their behavior modified over the simulated time, based upon their location, capability, etc. The classification hierarchy is: sensor type (FO, radar, etc.), sensor model, and individual sensor. For example, there may be numerous models of the forward observer type of sensor, each model describing basic, unique characteristics. There should be at least two models--one for the Red force and one for the Blue. There may be hundreds of individual sensors (e.g., forward observers) specified by the user; these FOs are assigned to host, or parent, units arrayed on the battlefield. The individual FOs operate at the host unit's location, searching for opponent units according to the performance characteristics specified by the model, as well as the parameters of the forward observer sensor type. The three ground sensors modeled in the COSAGE design methodology are:

(1) Forward observers (FO).

(2) Radars - countermortar (CM) and counterbattery (CB).

(3) Passive detection bases - sound (SD) and flash (FL).

5-2. FORWARD OBSERVERS

a. Forward observers that are represented within COSAGE are analogous to the forward observers that are trained and employed in battlefield tactics. A forward observer is (a copy of) a model and has the following basic characteristics:

(1) Name. The name is a user input value that assists him/her in data file creation, and may be used subsequently in the preparation of inputs, output file creation, or labeling and debugging of the FO model.

(2) Search Rate. This value is the rate in square meters per time period that an observer will search the target area.

(3) Equipment Identification. This is an input to identify the type equipment applied to a forward observer. Personnel are identified as equipments within a portion of the model

methodology; therefore, combat troops are an item of equipment, and the forward observer is normally set to this value.

(4) Range Band Set. The methodology incorporates range bands or range partitions to define the capability of a forward observer to search to given ranges or to acquire targets out to given ranges from its present position. The list contains the range partitions within which the forward observer operates. It is set to specific parameters created by the user that define the forward observers capability over the different ranges. The range bands have the following descriptors:

(a) Range. This value is the partitioning of the range to which the observer can see or acquire targets. It is a range segment within which its performance has distinct characteristics. For example, the user may specify four range partitions or range bands, and the values might be as follows:

Range band 1	:	from present position to 700 meters
Range band 2	:	700 to 1,200 meters
Range band 3	:	1,200 to 1,500 meters
Range band 4	:	1,500 meters to 1,800 meters.

In this case, four range bands have been specified, and, in this case, each range band has associated with it the following characteristics:

(b) Visibility. This value is the percentage of time or probability that a forward observer will be able to see a target within the specific range band given that line of sight does exist. It is expressed as percent x 100.

(c) Circular Error Probable. This value is the amount of error that would be induced by the forward observer in attempting to correctly locate a target within the specific range band. It is a function of the range from the forward observer to the target and is utilized in computing the target's estimated location.

(5) Probability of Detection. This input provides for a probability of detecting a type of target equipment given day or night conditions and the target's movement status, within each of the forward observer's range bands.

b. Individual forward observers are placed in maneuver units or any of the units in the force array through the creation of a unit sensor link. The unit sensor link has specific features which indicate its capability and functions; in this case, functions of a forward observer. Each unit has a list of sensors that belong to it, and the forward observer may be one of the sensors owned by the unit. Unit sensor links, of which the forward observer may be one, have the following features:

(1) A sensor type. The type is the index value of one of the previously specified types of sensors.

(2) A sensor model. This is the indicator pointing to, or referring to, a model of one of the forward observers.

(3) A host unit. This is the identity of the unit to which the sensor link belongs.

(4) Fire direction center assignment. This is the fire direction center to whom (the sensor i.e., forward observer) will forward target reports.

(5) A sensor status. The sensor may have three status modes in the course of the game. The status possibilities are:

0: hold - the sensor is inactive or interrupted, in which case it is not actively searching for targets.

1: active - the sensor is presently active and is searching for targets.

9999: this value is dynamically set during the course of the simulation to indicate that the sensor has been engaged by either indirect or direct fire weapons and has been destroyed.

(6) A sensor equipment identification. The equipment identification for the sensor link may be the same as the sensor model previously discussed and points to a particular type of sensor equipment. Forward observers are usually combat troops.

c. The methodology for forward observer modeling establishes the forward observer as a process. The forward observer searches, causes actions to be initiated, and then may cease to exist should it be a victim during the course of battle. The forward observer has the following features which support both the modeling methodology and the detailed design:

(1) Observer link to the parent (host) unit. This is a computer-generated number that identifies the forward observer in relation to its unit, be it maneuver or other category of unit.

(2) Observer relative direction. The forward observer has a direction established in the methodology and in the model to place it within the unit and establish the orientation that the observer will have on the battlefield. This is a precursor to the establishment of a search area for the observer.

(3) A current target report. This value is established dynamically during the course of the simulation and is the identification of the target report currently being processed by the observer.

(4) Forward observer search grid. Each FO has a grid established for the conduct of its searches during the course of the simulation. The grid is a 1,000-meter square to which the observer will apply his search efforts.

(5) Forward observer detecting candidate's unit list. The modeling methodology for the observer requires that each enemy unit lying within the observer's search grid be placed on a detectable candidate unit list. Once units are placed on the candidate list, they are subject to stochastic detections which are a function of line of sight, unit status, the FO's status, and other factors. The FO reviews this list every time it is in an active state. The FO may be placed in an inactive or passive state, at which time it is not searching, to handle other processes or activities.

(6) Forward observer target report list. Each FO maintains a record of target reports it has generated and that may be in process at the fire direction center.

(7) Forward observer current fire mission list. The FO maintains a list of the fire missions generated by the FDC which now reside at the firing battery in various states or status. The FO may be required to handle additional processing in support of the fire mission such as additional or follow-on volleys or fires to achieve the necessary coverage on the targeted unit.

(8) Once initiated, an FO continues to function throughout the simulation; it moves with its host unit, establishes new search areas, it may be interrupted due to other activities, and it may

be killed, in which case the FO is destroyed and any actions in process are destroyed. It is not replaced.

d. The following description of the forward observer's activities and actions is cyclic. It is a repeated process and is ongoing from the start of the simulation through the conclusion of the simulation. This discussion represents a single pass of the modeled activities of the forward observer. Throughout the observer's processes and activities, logic tests are made to confirm the status of the observer and to determine whether it is or has been killed. Should the observer be the victim of direct or indirect fires, the status is set as killed, and the observer's actions are terminated.

(1) The forward observer is established during data input and is placed with its host unit at that point. When the simulation is started the forward observer begins the process of developing targets, detecting potential target lists, detecting targets, etc.

(2) At each period of search, the forward observer first locates and establishes a search area which is a development of the search grid and his current location, based upon the host unit's location and its orientation.

(3) The forward observer then begins to establish a detection candidate or opponent unit list within the grid it has been assigned. If the FO is linked to a unit that is engaged in a battle, the FO searches only to make detections of those opposing units found within the local battle area. The FO does not search outside of the battle area.

(4) The FO systematically begins checking all of the detectable (candidate) units on his list. Any FO detection of the candidate units follows the following sequence:

(a) The targetable unit (opponent) is checked for its movement status to determine whether it is moving.

(b) The range to the targetable unit is checked against the observer's range band partitions. Additionally, a determination is made as to whether or not the target is within visible range.

(c) A probability of line of sight is computed based upon an exponential distribution of the range involved to determine whether line of sight does exist between the forward observer and the targetable unit. If the forward observer is an observer belonging to a maneuver unit, then a check is made to see if the opponent unit is one that is visible to the forward observer host unit.

(d) Degradation to the FO's vision is based upon the probability of acquiring visibility during daylight or darkness and is handled stochastically.

(e) The FO then systematically attempts to make acquisitions of individual items of equipment on the target unit's equipment list based upon the elementary PD input by the user (FO input) for the forward observer. A different PD may be input based on whether it is night or day, whether the opponent unit is moving, the equipment type, and the range band or range partition within which the observer is searching. Through Monte Carlo draws against the elementary probability of detection, the observer makes detections of various quantities of equipment and places those into a target report which is now generated. The detections will be analyzed later in the target report process.

(f) At this point, the FO begins completing the target report and establishing communication with the fire direction center to which the target report will be forwarded. If the

target is moving, an estimate of the movement rate is made and placed upon the target report as an estimated target location correction.

(g) The FO's CEP within this given range band is employed to establish and compute the estimated x and y location of the target. These values are then placed in the target report.

(h) The target's military worth is computed based upon the status of the target and the conditions of employment.

(5) Given the detection and the creation of a target report, the minimum and maximum transmit times for the observer to transmit or communicate the target report to the FDC is computed based upon a draw from the uniform distribution. The target report abort time is established as the current simulated time plus a delay specified by the user. The target report is communicated to the fire direction center and is placed in the FDC's target report processing queue and is subsequently acted upon.

e. The assessment of indirect fires on a unit that owns forward observers invokes logic to concurrently assess sensors or, in this case, forward observers. The assessment of killed forward observers is based upon the fractional casualties of the target unit. A random draw is made and should the personnel fractional casualties of the targeted unit be less than the random draw, the sensor (or forward observer) is flagged as killed. Once the sensor or forward observer has been killed, a flag is set to indicate the new status. The observer's actions and activities cease at this point.

f. The FO's searching process is interrupted if the fire mission includes laser guided munitions. This models the importance of the observer's duty to control the munitions to the target.

5-3. RADARS

a. Current methodology incorporates logic for two types of ground radar systems in support of the model ground forces. They are the countermortar and counterbattery radar systems. As with the FO, the radar sensors have specific features and characteristics within the methodology. These are as follows:

(1) The sensor has a model which is a user specified input value.

(2) The radar is assigned to one of the units arrayed on the battlefield and is colocated with that unit (typically an artillery or support unit).

(3) The radar as a functioning entity, though belonging to a unit arrayed on the battlefield, has a designated fire direction center to which it will report all information (target reports) received.

b. Radars, though differing in characteristics, all have the following features which are user input values (variables) that define or describe its operation and capability.

(1) A counterfire radar last on-or-off time. The radars are modeled with different cooperating characteristics, one of which is a period of operation followed by a period of inactivity. Therefore, each radar is tracked throughout the simulated period of time according to the last time it was turned on or off. The transmission time reduces its vulnerability in being detected by opposing radars.

(2) A counterfire radar orientation is the central direction toward which the radar will conduct its searches.

(3) A counterfire radar operator (CFR) is the method by which the counterfire radar is turned on and off. Target reports are generated and forwarded to the fire direction center via this mechanism.

c. Counterbattery and countermortar radars are modeled as receivers sensing enemy fire units. An indirect fire volley triggers the activation of counterbattery and countermortar radars. The sensing by counterfire radars occurs only within the sensor to which the firing battery is linked. There is no cross-sector or sensing missions unless the FDC structure is built accordingly. In each case, there is a 15-second delay from the time the volley or rounds are fired at the battery level until the counterfire radar or sensing process is set in motion.

(1) The volley of fire from an opposing battery unit sets in motion a counterfire radar activation if the radar is on. Once range checks are made to determine if range is less than or equal to the capability of the specific radar, the detection process is initiated. At this point, the radar type is established as either countermortar or counterbattery. Ranges less than 11,200 meters are designated as countermortar.

(2) In the course of the detection process, the following actions are taken:

(a) The direction and orientation of counterfire radar is computed against the direction of the targetable battery, and a test is made to determine if the targetable battery is within the fan of the radar unit. If it is within the fan, the probability of detecting the opponent battery within that range partition is set, and the CEP of the target location error is established.

(b) The performance of the counterfire radar may be degraded based upon the firing rate of the targetable battery. Detection is randomly determined based on the probability of detection. If detection occurs, the counterfire radar operation causes a target report to be generated and the target report information to be appended to it including the computed CEP of the target location and its estimated x and y location.

(c) Checks are made of comparable target reports at the FDC to ensure that there are no duplicates, and if there are duplicates found, these target reports are scrubbed from processing. If there are no duplicates, the target report abort time is established as the current simulated time plus a user-designated input, and the target report is forwarded to the FDC for processing.

5-4. PASSIVE DETECTION BASES

a. The methodology models passive detection bases to accommodate two types of battlefield phenomena associated with indirect fire or artillery battery employment. These sensors are passive in that they do not conduct searches for opponent units but do provide the base for a network of radar sensors. The two battlefield phenomena that are modeled and provide the stimulus are "sound and flash." The passive detection bases behave as human or electronic observation(s) of the firing of an artillery piece. A passive detection base (PDB) is assigned individually to a host unit. Each PDB has a model identification which defines certain capabilities. These are:

(1) Model PDB key (alert) time. This amount of time represents alert time or recognition of the firing by keyed sensors.

(2) Model name. This user-declared descriptor serves input file creation, output file labeling, and model debugging.

(3) Model PDB equipment identification number**.** This is the user-specified value of the type equipment that the PDB is classified.

b. Model PDB range band (partition) list. The methodology incorporates range partitions to describe the capability of the PDB and its operation over its maximum operating range. The range hacks may exist in the quantity the user deems necessary to describe the sensor's capability. The following descriptors are used:

(1) A range band (partition) range. This is the range segment within which the performance is described. For example, the user may specify four range hacks as follows:

Range band 1: present position out to 15,000 meters

Range band 2 15,000 to 30,000 meters

Range band 3: 30,000 to 40,000 meters

Range band 4: 40,000 to 60,000 meters

(2) A probability of detection for daytime and nighttime for each range band. This value is the probability that the PDB will detect the sound or flash in the given range partition, under the conditions.

(3) A circular error probable in location for daytime and nighttime for each range band. This value describes the capability of the PDB in estimating the source (battery) location of the sound or flash in the given range partition under the conditions.

c. PDBs are linked to host units and may also be linked to ground radars. The linkages serve the function or operation of the sensors, given the model descriptors above.

(1) The unit sensor link places the sensor at the specified unit in the force array. The unit sensor link has specific features which govern its capability with the host unit. The PDB may be one of several sensors linked to the particular host unit. The unit sensor link has the following features:

(a) A sensor type. This value is the index value of one of the types of user specified types of sensors.

(b) A sensor model. This is the indicator pointing to one of the models of PDBs which have specific operating characteristics.

(c) A host unit. The number of the unit to which the sensor is linked and colocated.

(d) Fire direction center assignment. This is the FDC to which this specific sensor will forward all generated target reports.

(e) A sensor status. The sensor (PDB) does not retain a status; it is the conceptual linking of other sensors which do have a status.

(f) A sensor equipment identification. The equipment identification is from the user-developed equipment list and should be the same utilized for the model description.

(2) Each individual PDB, in addition to the linkage to its host unit, has features to support the methodology as follows:

(a) PDB unit sensor link: this is the identifier of the previously discussed linkage for cross reference purposes.

(b) PDB operation status: the passive detection base operator is either flagged to be idle (0) or is currently busy (1) in processing a target report.

(3) Each passive detection base behaves as a host, or central node, with a simple network (individual nodes) of sensors keyed to it. Each of the "subordinate" sensors are radar sensors which function as individual sensors. Each PDB maintains the network of sensors keyed to it through a keyed sensor list. A keyed sensor type is the cross-reference to one of the types of sensors created by the user; it must be one of the types of radars (counterbattery or countermortar) if radars are to support the target acquisition process.

(4) Each PDB maintains a list or operating queue of the opponent firing units it has successfully detected. These detected units may be retained in the list until a target report is generated. The information retained on the PDB detected unit is as follows:

(a) The battery (indirect firing unit) detected.

(b) The PDB's CEP in correctly locating the battery at the range and in the day/night conditions.

(c) The PDB probability of detecting the battery according to its type, at the range and day or night conditions.

(d) The priority or threat as indicated by the military worth of the type of battery detected.

(5) Each modeled PDB resides in a set of available PDBs for the force or side. In the course of the simulation, the specified PDBs that are activated and employed in detection attempts are all the PDBs found to be in sensing range (by operating characteristics) of the firing battery.

d. The methodology for passive detection base modeling establishes the PDB operation as a series of events on the battlefield, consummated (if successful) in a target report to an FDC. The events and their features that support the methodology are as follows. In every case, the sequence is initiated by an opponent indirect firing unit firing a volley of munitions.

(1) PDB activation. The activation is an event set off by the fired volley. In every case of firing, two activations are initiated: one for flash, which occurs simultaneously, and a second for sound, which occurs at computed time delay to allow for the speed of sound based upon the battery to FLOT distance. Each event has the following features:

(a) PDB activating battery - the battery that fired the volley.

(b) PDB activation type - flash or sound.

(2) If the PDB is operating, but idle, and the PDB is successful in making a detection, an event is made to activate the PDB's operator. If no detection is made, each of the keyed sensors (radars) is alerted to attempt a sensing for detection.

(3) The operation is an event set off with the successful detection by any of the PDBs activated. The operator creates and submits the target report to the appropriate FDC. The PDB operation has two values associated with it for recordkeeping:

(a) PDB sensor identification - the number of the PDB that has made the detection.

(b) PDB detected unit - the identification number of the battery that fired the volley.

(4) Should the PDB not explicitly make the detection, the keyed sensors (radars) networked with the PDB may be activated; in this case, the sequence of events or activities discussed under the paragraph on radars is invoked.

e. The following description of the PDB's activities and actions is repeated for each volley of fire by an opponent firing battery. It is event driven, which means that specific acts must be successfully completed before the PDB operates. This discussion represents a singly initiated PDB sequence. It is initiated for every volley fired during the course of the simulation.

(1) The sensor is established during model initialization. At that point, the user's data establishes the passive detection base and its characteristics as a sensor with a network of keyed sensors. The keyed sensors identified must also be stated elsewhere as sensors (radars) within the user's data file. At this point, the organization characteristics are set and will wait the start of the simulation and the first stimulus (indirect fire unit volley) which sets the passive detection base into operation.

(2) At the time that the volley is fired, a passive detection base activation (event) is acted upon assuming that the muzzle flash travels at the speed of light.

(3) Concurrently, a PDB activation is initiated in the time that is required for the sound or report of the firing to reach the FLOT from the firing battery's location. A counterfire radar activation is set in motion 15 seconds after the volley is fired.

(4) At the moment the PDB activation is simulated (there is one for flash, and one for sound), the type of activity that is modeled, i.e., sound or flash, is established, and a search of the PDBs in the sides' PDB set is checked. During the course of this check, the range from the firing unit to the location of the PDB is computed. If the gun to sensor range is less than the largest range hack in the PDB's range band list, then the PDB detection is scheduled.

(5) If the firing unit is beyond the PDB's maximum range, the particular model cannot acquire the target, and the sequence is terminated. Otherwise, the detection probability for a flash type sensing is established based upon the conditions of night or day and the range partition. If the sensing type is sound, the report or sound is degraded based upon the noise of the enemy firing. That is, the number of fires within a specific time period and the actual range of the firing unit to the sensor. Each of the volleys contributes to the rate of firing. The major factor for sound detection is a function of the enemy artillery's firing rate.

(6) The computed probability of detection is placed against a random draw; if the logic test is passed, a detection is completed, and the detected unit is established and placed into the passive detection base operator's queue. If the PDB operator is idle, the initiation of the operator is scheduled at this point in time. Otherwise, it is sequentially processed in the order in which the detected unit was placed on the operations queue.

(7) In the event that the random draw against the detection probability is unsuccessful, each of the keyed sensors (radars) within the passive detection base's keyed sensor list is checked, and the counterfire radar is switched on to all of the keyed sensors that qualify.

(8) The PDB operator processes the detected unit by creating a target report with the following information:

(a) The targeted battery.

(b) The sensor type, in this case, PDB

(c) The sensor identification, or in this case, the PDB's identification.

(d) The FDC to which this target report will be forwarded is identified.

(e) The reporting unit which is the host to which sensor is linked.

(f) The CEP in correctly locating the targeted unit based upon the CEP for the PDB under the conditions (day or night) at the appropriate range.

(g) The estimated location of the targeted unit is computed utilizing the CEP and a random draw off a normal distribution.

(h) The detected equipments within the targeted unit are established based upon the number of howitzers in the battery set.

(i) The target report receive time is established as the current time and the abort time is set to the current time plus a user-specified input.

(j) A check is made comparing this target report against other target reports; in the event a duplicate target report is indicated, the target report is scrubbed from the processing. In the event that there is no duplicate, the target report is initiated at this current time without any delay.

(9) At this point in time, the next detected unit that may be residing on the PDB's operating queue is acted upon. Through the scheduling of the counterfire radar process, the events are set in motion to cause the counterfire radars to search and attempt to locate the battery that fired the volley. Refer to preceding paragraphs on the discussion of counterbattery and countermortar radars for a description of the activities and processing conducted by those types of sensors.

5-5. REASONING AND LOGIC

a. The methodology for ground sensors, previously discussed under the functional characteristics of each, provides the basic logic structure. The functional aspects of different sensors mandate separate representations (models).

b. The basic modeling entity is the sensor type, which is the method of classifying the fundamental features of sensors by their military grouping; i.e., forward observers, radars, and passive detection bases.

c. The user may create numerous models of a sensor type giving each model specific operating characteristics or parameters that describe its performance on the battlefield. This provides for modeling flexibility.

d. The user may create the modeled force with the appropriate quantities of sensors of a given model and type to define the capability of the force. This supports the development and modeling of stylized force arrays with future capabilities.

5-6. LIMITATIONS AND ASSUMPTIONS

a. Sensors are assessed losses during the simulation based upon indirect fires (artillery) and minefield effects on the host unit.

b. Sensors, when lost by the host unit, are permanent losses, and the capability is lost by that side. There is no direct transfer of sensor functions to a surviving asset (forward observer duties, for example). Refer to Volume III, Applications Guide, for indirect methods to accomplish a transfer of sensor function.

c. The communications links between the sensor and the FDC are perfect, and the system has an infinite capability of assimilating the information regardless of volume or frequency.

5-7. ALGORITHMS. The methodology incorporates the following algorithms in support of the ground sensor modeling.

a. Noise degradation is calculated for the passive detection base type "sound" to model the effects of distance from the source (gun report). A distance from firing piece to sensor of greater than 15,000 meters is considered beyond carrying range (dampened out) and is disregarded. The number of "reports" (volleys) with a range of less than 15,000 meters, occurring within 1 minute are counted. Let NR = counted number of reports. Let P (Det) = probability of detecting the firing unit.

If NR is less than 5,

$$P\ (Det) = 0.1566.$$

If NR is less than 10,

$$EXP = 3.0.$$

If NR is 10 or greater,

$$EXP = 0.895 \times NR \times 2.105.$$

then

$$P\ (Det) = 1 - (1 - 2/NR) ** (1/EXP).$$

The P (Det) is compared to a random draw to determine success of detection.

b. Target location error, or the inability of the sensor to accurately estimate the location of the center of mass of the target unit is computed through the application of error parameters (CEP) for each type sensor over range (partitions) and may be influenced by day or night conditions. The following computations are used:

where .NDF = random draw from a standard normal distribution function, with a mean of 0.0 and standard deviation of 1.0;

CEP = circular error probable in meters, a user input, for each sensor model;

and X and Y represent the actual unit location in meters.

$X' = X + .NDF \times CEP/(1.1772)$

$Y' = Y - .NDF \times CEP/(1.1772)$

CEP is 50 percent of area under the circular normal distribution curve; the 1.1772 factor is applied to the divisor to convert CEP to a standard deviation.

c. Forward observer's probability of possessing line of sight in making detections on the open battlefield (not in a local battle) is computed as follows:

where R = observer to target unit range in decameters,

$P(LOS) = .54 \times e^{(-.0037 \times 16 \times R)}$

The 16 factor converts the meter value to hexadecameters as called for in the equation.

The computed P(LOS) is tested against a random number (draw); if the value is greater than the random value, a successful line of sight has been established.

d. Forward observer's capability to see a target, at a range, given that line of sight exists is expressed in the forward observer's visibility (a user input) by range partition. The value is the probability that the observer will not see the target.

Let degradation = probability of visibility = P(V), within a given range partition.

If the simulated clock is at nighttime, then let Pct.Vis = percentage of daytime visibility that exists at night, and degradation = P(V) x Pct.Vis.

Otherwise, degradation = P(V).

If the computed value for degradation is less than a randomly drawn value, the observer is considered ineffective, and no detection is made.

Section II. UNMANNED AERIAL VEHICLES (UAV)

5-8. GENERAL. COSAGE design methodology incorporates UAV sensor capability. The sensors modeled behave according to FO methodology accounting for an elevated slant range and specialized optics. The purpose of UAV activity in searching for opposing units is to generate and transmit target reports to fire direction centers for processing into fire missions. Additionally, UAVs can loiter over a target, lase the target, and guide specialized munitions to the target.

5-9. UNMANNED AIR VEHICLES. The characteristics of each UAV are as follows:

a. Types. The number of UAV types described below.

b. Name. The name is established by the user during data input to assist in data file creation, output file labeling, and model debugging.

c. UAV Side. The side owning the UAV.

d. UAV Altitude. The average flight altitude.

e. UAV Penetration. A switch to indicate whether this type of UAV flies deep cross FLOT or close-in reconnaissance missions.

f. Minimum Target Distance. Minimum distance during loiter to the target.

g. Maximum Target Distance. Maximum distance during loiter to the target.

h. UAV Action. The methodology uses administrative (ADMIN) type orders for initiation, including the development of the flight profile.

(1) Once the UAV is prepared for flight, it is launched to fly the prescribed flight profile.

(2) During the course of executing each leg of the flight profile, it conducts searches for opponent units. If the range to an opponent unit is less than the UAV's maximum sensing range, the UAV attempts to detect the unit.

(3) Detections are stochastically made on the candidate units on the list, based upon the units environment and quantities of equipment in the candidate target's area. The elementary probability of detecting and acquiring the equipment is computed. The computed probabilities are tested against a random draw. Given a successful detection and an acquisition, the acquired quantities are summed. If the acquired quantity is greater than zero, a target report is generated and the target data appended to the report.

(4) The target report is transmitted to the appropriate FDC and the received time appended to the report. The abort time is established as the received time plus 30 minutes (a user input).

(5) Upon completion of the flight profile, the UAV is returned to the host unit location and is set in a hold (inactive) status until the next mission is required.

5-10. REASONING AND LOGIC. The logic for UAVs has been presented in the functional description for forward observer.

5-11. LIMITATIONS AND ASSUMPTIONS

a. The limiting function of an UAV to lase more than one target equipment per unit is the speed at which the reticle (optical cross-hair) can be reset. Currently, this is set at 30 seconds.

b. Altitude should be adjusted from scenario to scenario depending on the threat air defense capability and the degree of target resolution desired (i.e., flying closer to the ground increases the probability of target acquisition but also increases the probability of getting shot at by air defense artillery (AAA)).

CHAPTER 6

SMALL UNIT ENGAGEMENTS (BATTLES)

Section I. GENERAL

6-1. MANEUVER UNITS

a. The maneuver unit is one of the unit groupings modeled within COSAGE. The definition requires that the user designate a given unit as a maneuver unit in unit input. The maneuver unit designation carries with it the capability to maneuver throughout the battlefield according to certain user-input (command and control) orders, and certain sets of embedded logic that govern the activities of the maneuver unit. The maneuver units are those commonly accepted in military tactics as capable of fire and maneuver: armor, mechanized infantry, and infantry. The units so modeled have no indirect fire capability such as mortar sections or other organic indirect fire (area type) weapons. All indirect fire type weapon systems must be modeled as batteries and are discussed in the chapter on artillery employment. Direct fire weapons organic to the maneuver units employ a single shot probability of kill methodology in the assessment. Maneuver units are linked to the unit structure via data input and are also linked to type units and equipment lists through the data structure. Each item of equipment that belongs to a maneuver unit may have weapon system(s) mounted on it. Weapon systems have certain descriptors that govern the engagement of opposing target items of equipment and their assessment, to include ammunition expenditure results.

b. A maneuver unit's organizational structure is based upon the hierarchy or organizational structure provided when the unit information is input to the model. In this manner, units identified as maneuver units that have subordinate units are linked into task force organizations within the model. The task force organization is such that the highest unit with a set of orders forms a task force of all its subordinates and all of the subordinate's subordinates into an organization with a common set of orders. The formations input by the user at the time of unit input are maintained throughout, and the units execute the orders up to the point when drawn into a battle. Therefore, the user should be aware that the organizational formation or its array as depicted is the tactical formation in which the units maneuver and move on the COSAGE battlefield.

6-2. SMALL UNIT ENGAGEMENTS

a. As the maneuver unit task forces execute their orders and perform aggressive moves (for example move to coordinates), the model logic requires a proximity test be performed at the point each maneuver unit completes a segment of its move. In the event that the aggressive movement of a force's units come into the activate battle range, small unit engagement logic begins, and the battle may be started. Task forces may be astride sector lines and also may be drawn into battles in either sector. As previously mentioned, the sector is an artificial division of the battlefield in a lateral fashion and is not equated to any sector orientations as treated in normal military tactics. In the event that the proximity test is satisfied, an attempt is made to get the next order for that maneuver unit. If the maneuver unit has an attack order in its orders set, a battle is activated. As the attack is activated, a local battlefield is set for the ensuing small unit engagement. The terrain is established upon which the battle will be fought. Logic tests are performed on the units in proximity of each other to ensure that they are opponents (i.e., direct fires are not exchanged between units of the same side).

b. The small unit engagements or local battles on the COSAGE battlefield are the part of the methodology in which direct fire engagements occur. The small unit engagement is invoked

when opposing units come within the activate battle range (a user input in system input), and the battle is drawn. At that point a different set of logic and methodology is invoked to model the activities of the combatants. The other activities occurring on the total COSAGE battlefield impact on the small unit engagement, but the small unit engagement events, actions, and results are unique to the battle. Small unit engagements are generally composed of maneuver units. Attack helicopter units or teams may be drawn into the battle, and, of course, indirect fire or artillery employment is a part of the battle. It is within the small unit engagement that obscuration, dust, visibility, and other "operational" parameters occur.

Section II. TACTICAL BATTLE

6-3. THE LOCAL BATTLE

a. At the initiation of the local battle or small unit engagement, the local battle structure for each side is created. In the process of creating a force, the total number of critical items of equipment in each unit of each force are summed for computations, and the decision point for the force's actions is established, based upon the decision value by mission and by side. Therefore, the decision criteria input by the user (see Decision Input) drive the missions and the force (side) employment within each local battle or engagement.

b. It is at this point the priority for attack helicopter support of a given side's force in the local battle is computed and established. The priority for attack helicopter support is based upon the support mission priority for the mission, the side, and the number of units being supported. Also included is the support priority for the unit types involved in the battle. Also, a factor that is summed is the type of unit opponent priority value. The four values are then multiplied to compute the attack helicopter support priority for the battle that is about to commence. At this juncture, the type of battlefield is established. The methodology allows for the user to predefine, or establish, templates for several types of battlefields; however, this portion of the methodology is not active within the COSAGE Model, and the type of battlefield is always established as one for the general battle scenario. Within the general battle setup, the maneuver units are oriented from Red center of mass to Blue center of mass within each force. Their missions establish the distance of attack and the distance of withdrawal, which will be utilized throughout the duration of the battle (see Application Guide (Vol III) for more details). Points which create a path for each maneuver unit to maneuver or advance and withdraw are established within the battle. The headquarters units are offset and identified for the battle, and the general battle parameters are established. At this point, the units of each side that form the fighting forces begin to establish line of sight to the opposing units, with enemy detections being made, movements initiated, and forward observers directing their searches on the opponent units. This is followed by a check of helicopter support priorities, and in the event the support priority is high enough, helicopters are employed. Helicopters then commence their movement to the battle area.

Section III. WEAPON CHARACTERISTICS

6-4. DIRECT FIRE ENGAGEMENT

a. Line of Sight (LOS). The methodology for the engagement of units requires that first the line of sight be established between opposing units. Line of sight methodology requires that each of the Blue units attempts to acquire each of the Red units and then each the Red units attempts to acquire each of the Blue units. In the LOS calculations, the following steps are performed for each of the Blue units attempting to establish line of sight to each of the Red units, and vice versa. In the methodology, if a Blue unit has line of sight to a Red unit, then the Red unit also has line of sight to the Blue unit.

(1) The status of the unit is evaluated and, depending on whether the unit is stationary, moving, or moving to stationary, the terrain value for the type of terrain (which is established by the user in input) is used to determine LOS breaks. The type-terrains each have a stationary line of sight break range, a moving line of sight break range, and a moving to stationary line of sight range.

(2) The second value that is employed in the computations is the actual range between a Red unit and Blue unit.

(3) Another value that is employed in the target acquisition computaÛtions is the line of sight probability given the type of terrain and line of sight range band. The line of sight range band is a partitioning of the possible ranges into different segments or incremental values, with each of these range bands having (with a terrain) a probability of achieving line of sight. Then, in a random draw against the line of sight probability in the range, line of sight may or may not be established.

(4) Next, the methodology requires the use of Weibull shape and scale parameters for each type of terrain. This is where the topography of terrain comes into play. The length of the line of sight segment is drawn from a Weibull distribution with the appropriate shape and scale parameters. In this manner each of the opponent units have either been established on a line of sight list, or have not been placed on the line of sight list. The appropriate computed line of sight segment is then calculated and is linked to the acquired unit.

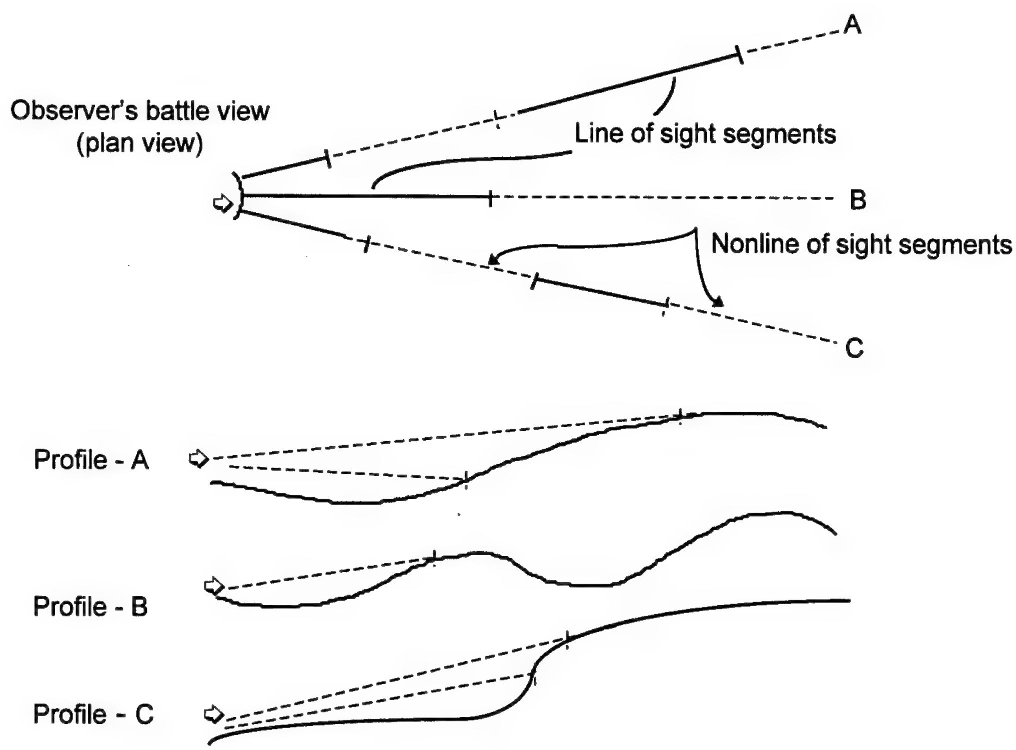

Figure 6-1. Line of Sight and Nonline of Sight Segments

b. Time to Detect. Based upon the opponent units that are placed on the line of sight list and which are given a line of sight segment in the preceding paragraph, times to detect are computed. It is at this point that the detections of individual items of equipment are made in the opponent units by the equipment and weapons of the searching unit. The time to detect is based upon the individual weapon sensors and their capabilities. There is a distinction between the detecting unit and the detected unit, and the detected unit may not be aware of the opponent unit. The search algorithm employed in computing the time to detect provides for temperature attenuation, target resolution, frequency of the detected equipment, and other parameters. A good treatise of this topic is given in CAA Study Report CAA-SR-88-33, Sensitivity Analysis of COSAGE II, Chapter 4, pages 4-1 through 4-10. The algorithm also uses a fractional percentage of the target visible which is a randomly drawn value. Each weapon system may have several sensors on it which may represent infrared sensors or other optical sensors. At present, there are provisions for three types of sensors, one of which is the human (naked) eye. Once the time to detect has been computed, engagements are scheduled between the detecting and the detected unit. At this point, the detecting unit is preparing to fire at, and engage with, the opponent or detected unit with direct fire weapons. The acquisition values employed here are input in type weapon input as follows:

(1) Type Weapon Type of Sensor. The type of sensor may be one of the following.

(a) Unaided eye - human capability.

(b) Tank thermal sight (TTS).

(c) TOW infrared sight.

(2) Type Weapon Number of Sensors. The quantity of observers or mounted sensors that can search for opponent equipments for engagements and influence the fire control over the weapon system.

(3) Type Weapon Spectrum for the Type of Sensor. Each sensor has a spectrum for its search, which may be one of three types:

(a) Visible light.

(b) Spectrum of light values 3 to 5 microns.

(c) Spectrum of light values 8 to 12 microns.

(4) Type Weapon Vertical Field of Search for the Weapon Sensor. This value is input in degrees and is the angular height of the area over which the sensor conducts a vertical search. It is assumed to be measured up from the horizon.

(5) Type Weapon Vertical Field of View for the Weapon Sensor. This is the angular height of the area seen by the sensor in viewing. The vertical field of view is assumed to be up from the horizon.

(6) Type Weapon Horizontal Field of Search for the Weapon Sensor. This value is input in degrees and is the angular width of the area over which the sensor may scan.

(7) Type Weapon Horizontal Field of View for the Weapon Sensor. This is the angular width of the area seen by the sensor in viewing.

c. Direct Fire Noise (explosion). The methodology incorporates direct fire noise modeling resulting from the exchange of medium and large caliber weapon fire between battling forces. A direct fire rate list is maintained and holds a record of each "shot" made by a weapon firing munitions of greater than 10 pounds weight. This "noise" is evaluated by the passive detection bases which may also be attempting to make sensings on indirect (artillery) fire. Thus, the direct fire noise introduces sensings which may be degrading to the performance and/or accuracy of the passive detection bases.

d. Firing Tables. The engagement initiation calls for the establishment of firing tables between the shooting equipment and the target equipment of the opponent units. These tables illustrate static probability of kill values from which various threat weapons are prioritized for fire allocation. Shoot outs, which model the engagements in which kills are made, are then commenced. At this point in the battle, defensive FASCAM may be requested, illumination may be requested, as well as smoke munitions by the detecting unit. Also at this point, the illumination rules for the side and the mission of the detecting unit are employed to determine if the request will be honored. The smoke use rule of the side and mission of the detecting unit is also invoked.

e. Shootout. It is in the shootout methodology that different equipments engage the opponent unit's equipments on an individual basis. The methodology for shootouts calls for the preparation of a set of firing tables for each firing equipment, which then is set to different values based on the possible targets at which the equipment may shoot. Each possible target is weighted, based upon range and the probability of that firer's successfully shooting and killing the opponent equipment item. The opponent's capability as represented by its PK is also factored in to create a threat value. This precludes such irrational actions as a combat soldier with an M16 rifle attempting to engage and kill an opponent tank, whereas he would most likely engage opponent soldiers equipped with small arms as well. Likewise, it would preclude a tank from engaging a soldier when it should actually be engaging opposing tanks. The shootout process also incorporates certain delays which may be the acquisition time and the time required for the flight (trajectory) of the projectile fired by the weapon. It establishes, through random draws, the kill or nonkill status of the opponent (engaged) item of equipment. Whenever a kill is assessed, a check is made of the thresholds for close air support. If any of the thresholds have been exceeded (e.g., the ratio of Red to Blue tanks in the battle exceeds SD.MAX.TK.RATIO(RED or BLUE), a requirement for close air support may be generated.

f. Decision Thresholds. Every engaged unit is evaluated based on the unit's mission, side, and effectiveness level. In the event the critical equipment onhand within the unit is below the break point percent (threshold), the unit may be ordered to withdraw from its present location. At the next check of the battle, if a unit has been attrited below the minimum effectiveness level, it is identified as a "dead unit." It is then removed from the task force list and from the battle force. Its order set is changed, and it is instandly moved to the rear for a distance of 20 kilometers. The unit disclosed as a "dead unit" is removed from the force structure from which it previously existed. If a headquarters unit is decimated, the next lower unit assumes the headquarters role and assumes the orders of the now defunct task force leader.

6-5. PROBABILITY OF KILL METHODOLOGY. This data is discussed in greater detail in CAA-TP-92-3, COSAGE Probability of Kill Methodology - Basic Data Requirements.

a. The direct fire weapon system's assessment methodology is based upon the single shot probability of kill capability of a weapon, given a target (type), at a range from the firer. There are three types of kill probabilities employed by the military analytical community: (1) probability of a mobility kill, given a shot (PK/M), which renders the target equipment immobile, but repairable, (2) probability of a firepower kill, given a shot (PK/F), which renders the target equipment incapable of returning fire, but capable of leaving the battle under power,

possibly to be repaired, and (3) probability of a catastrophic kill (PK/K) which renders the equipment a total loss. Each PK type represents an escalating degree of difficulty or a lower probability in achieving the type of kill. The PK type represents a family of analytically consistent data and is normally determined by the study director. The user/analyst must input PK data of the same type for all weapon systems modeled. Normally, the PKs employed in COSAGE are PK/M/F. This is a combination of mobility and/or firepower kill given a shot.

b. The COSAGE application treats all type kills, regardless of the PK data employed, as an equipment loss to the owning unit. The PK methodology brings together the weapons (by type) and the equipments (as targets) in probability of kill tables.

c. The primary goal of COSAGE is to take a static (laboratory) PK value and convert it, under simulated battle conditions, to an operational PK. (See Volume III, Applications Guide, for further details.)

(1) Type Weapons. Each of the individual weapon types are linked to a host equipment at the individual unit (TOE) level. Each weapon modeled has the following operating characteristics input by the user in weapon input.

(a) Name. The generic or military nomenclature may be used to support data file development, output file labeling, and debugging.

(b) Rate of Fire. The rounds per minute the weapon is capable of firing in its normal employment (sustained fire) mode.

(c) Round Velocity. The speed of the round.

(d) Round Weight. The weight of the projectile and casing, used to compute tonnage extended during the course of the simulation.

(e) Minimum/Maximum Range. The effective ranges, employed in shootouts and probability of kill computations.

(f) Basic Load. The number of rounds normally placed onto the weapon system in a combat environment. This value is currently only used for air defense, Air Force, and Army aviation assets.

(g) Probability of Kill Pointer. The methodology groups type weapons into analytically compatible sets or families for the PK value selection (from a matrix) and computation. This value is the number of the row in the PK matrix for this weapon.

(h) Firing on the Move Pointer. The methodology provides for each type weapon to select PK values based upon the movement status of the firer and/or the target equipment. This value is the row number in the matrix for this weapon.

(i) Night Factor. This value is currently unused.

(2) Equipments. Each modeled equipment, in addition to having certain operating features specified by the user, is linked to a type equipment for dimensions (height and projected area), and is linked in the unit equipment list to a weapon. Equipment PK column numbers address equipment as targets (weapons in weapon input are addressed as shooters).

(3) PK Matrixes. The linking of a firing weapon to a target equipment via probability of kill for assessment of direct fire shootouts is accomplished through matrices of data created by the user.

(4) Firer Movement Determination. The movement status of the firing equipment system is determined by the status of the host unit. If the unit is advancing or withdrawing, and the the firer to target equipment range is less than the terrain type's fire movement range, then the firer is moving.

(5) Target Movement Determination. The movement status of the target equipment is also determined by the status of the host unit. If the unit is advancing or withdrawing, and the target to firer range is less than the type terrain's fire movement range, then the target equipment is moving.

(6) Defilade Determination. If the targeted unit is stationary, it is assumed to have all equipment in defilade. If it is moving, its equipment is considered to be in the open unless it is at a range greater than the type terrain's defilade range; then it has all of its equipment in defilade.

An exception to these rules applies if the target unit is delayed by a minefield; all its equipments are assumed to be in the open until the minefield is cleared.

c. The type weapon PK pointers and the equipment pointers provide the basic modeling technique in representing the firer-target relationship. The PK data is empirically and analytically produced. This data is then acted upon by factors, also analytically produced, to accommodate the various battlefield situations. There are six situations for which a factor may be applied (Figure 6-2). The details of probability of kill modeling follow.

		Stationary open	**Stationary defilade**	**Moving**
Firing weapon status	Stationary	1	2	3
	Moving	4	5	6

Figure 6-2. Shooter/Target Matrix

(1) Situation 1. A status of stationary and not in defilade for both firer and target equipment is the basic condition in the PK methodology, the other situations being permutations accounted for in the discussions to follow. The features described below provide the fundamental technique in the shootout methodology for computing the probability of kill. During the simulation, the computed PK is tested against a randomly drawn value in a Monte Carlo scheme to determine a hit or miss of the target.

(a) PK Band. Range partitions are the basic structure for the probability of kill curve which is used to divide a given weapon's effective range (minimum to maximum) into equal intervals; 11 range points or 10 partitions are employed.

(b) PK Vector. These 11 PK data points as a function of range are now thought of as a vector. The vector is pointed to by the PK pointer. It allows aggregation of the weapon/equipment combinations. The user provides sufficient vectors for the weapon systems.

(c) Probability of Kill. The elementary probability of kill, given a shot associated with a vector (aggregation within a range band or partition).

(d) PK Pointer. These are two two-dimensional arrays sized as the number of weapon pointers by the number of target equipment pointers, one array for open and the other array for defilade pointers. Each position in the pointer array is set (by the user in data input) to one of the PK vectors described above. Therefore, during a shootout, the value of the type weapon's PK pointer and the value of the target equipment's PK pointer is employed on this matrix to acquire the value of PK vector, and, based upon the range, the probability of kill is computed from the PK curve. Figure 6-3 illustrates how the data structure for PK pointers relates to the PK vectors.

Probabilities of kill given a shot/burst as a function of range

PK vectors

Vector number											
1	99	46	32	28	22	20	17	14	11	8	0
2	85	76	72	68	62	50	47	34	21	0	0
3	65	56	42	38	22	10	10	0	0	0	0
4	45	45	45	45	45	45	45	45	45	45	45
5	35	30	25	22	18	10	0	0	0	0	0
6	25	20	15	8	0	0	0	0	0	0	0
7	10	8	5	4	1	0	0	0	0	0	0
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

Open PK pointers

Target number

Weapon numbers	1	2	3	4	5	6	7	.	.	.	.
1	7	8	102	34	87	87	87	.	.	.	.
2	13	422	386	781	5	6	0	.	.	.	.
3	286	107	4	4	4	0	0	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

Defilade PK pointers

Target number

Weapon numbers	1	2	3	4	5	6	7	.	.	.	.
1	1	8	110	4	62	62	62	.	.	.	.
2	22	42	36	71	44	0	0	.	.	.	.
3	113	122	86	81	9	6	0	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.

Figure 6-3. PK Structure

(2) Situation 2. The situation of a stationary firer attempting to engage opponent equipment items in prepared defensive positions (in defilade, or masked behind terrain features) is modeled through the following descriptors. These descriptors parallel the techniques employed in the basic condition (Situation 1).

(a) PK Defilade Pointer. This is a two-dimensional array sized as the number of weapon pointers by the number of target equipment pointers. Each position in this firer by target array has a PK vector value (previously described), which becomes the basis for the PK curve selection and subsequent PK computation. Therefore, in a shootout, the value of the type weapon's PK pointer and the value of the target equipment's PK pointer is employed on this matrix to acquire a value of PK vector and then, based upon the actual firer-target range, the probability of kill is computed from the PK curve.

(b) Monte Carlo Draw. During the simulation, the computed PK is tested against a randomly drawn value to determine the hit or miss of the target.

(3) Situation 3. The situation of the stationary firer attempting to engage moving opponent equipment items is modeled through the following descriptors. These features parallel the first situation.

(a) PK Movement Band. These bands or range partitions are similar to the described PK bands. They provide the basic structure for a probability of kill degradation curve. The degradation factor is used to factor the elementary, computed PK as discussed in Situation 1. The bands divide the range between firer and target. Currently, there are six bands or partitions defined.

(b) PK Movement Range. Each band or partition described above has a maximum range associated with it to be applied as an upper bound.

(c) PK Movement (vector). The vector provides an index or vector number to which the type weapon fire on the move pointer refers. Therefore, the number of vectors and the range of values employed in the type weapon description must agree.

(d) PK Movement Factor. This is elementary percentage of degradation applied to a computed PK for the type weapon in a specified PK movement band.

(e) Target On-The-Move Qualification. The user controls the capability of firing weapons to engage moving targets via a firer (weapon) by target (equipment) matrix which holds yes or no flags denoting that the firer is or is not qualified to engage the target on the move.

(f) Operational PK Calculation; Scenario 3. During the simulation, when Situation 3 occurs, the target on the move status is first checked to determine if the firer qualifies to engage the equipment. If qualified, the PK is then computed as described under Situation 1. The firer-target range is again evaluated, the appropriate movement range (band) is established, and based upon the type weapon's fire on the move pointer, the movement factor is selected from the matrix. The basic PK is multiplied by the movement factor to realize an adjusted PK value. The final PK value is logically tested against a randomly drawn value to determine (record) a hit or miss of the target.

(4) Situation 4. A moving firer attempting to engage a stationary target is modeled through the following descriptors. The conceptual PK movement band and PK movement range presented under Situation 3 apply in this Situation.

(a) PK Movement (vector). The vector (is a technique which) provides an index or vector to which the type weapon fire on the move pointer refers.

(b) PK Movement Factor. This is elementary percentage of degradation applied to a computed PK for the type weapon in a specified PK movement band.

(c) Firer on the Move Qualification. The user controls the capability of a moving vehicle's ability to engage targets via a firer's (weapon's) by target (equipment) matrix.

(d) Operational PK Calculation; Scenario 4. During the simulation, when this Situation 4 occurs, the firer on the move status (matrix) is first checked to determine if the firer qualifies to engage the equipment. If qualified, the PK is then computed as described under Situation 1. Then, the firer-target range is again evaluated, the appropriate movement range (band) is established, and based upon the type weapon's fire on the move pointer, the movement factor is selected from the matrix. The basic PK is multiplied by the movement factor to realize an adjusted PK value. The final PK value is logically tested against a randomly drawn value to determine (record) a hit or miss of the target. The movement factor data is empirically and analytically derived and is influenced by the weapon systems stability and fire control capability while moving (i.e., gimbaling).

(5) Situation 5. The situation of a moving firer attempting to engage a stationary target in defilade is modeled through the previously described shoot out features in the following manner.

(a) PK Defilade Pointer. This array, which points to a PK vector value, is employed as described under Situation 2, as opposed to the PK pointer array referred to in Situation 1. The use of this pointer produces a PK based on range and the defilade status of the target equipment.

(b) PK Movement Factor. This is elementary percentage of degradation applied to a computed PK for the type weapon in a specified PK movement band as described in Situation 4.

(c) Firer on the Move Qualification. As described in Situation 4, the user controls the capability of a moving firing weapons ability to engage targets.

(d) Operational PK Calculation; Scenario 5. During the simulation, when Situation 5 occurs, the firer on the move matrix is checked to determine if the firer qualifies to engage the equipment (in defilade). If qualified, the PK is then computed based on the PK (defilade) vector and range. Then, the firer-target range is again evaluated, the appropriate movement range (band) is established, and based upon the type weapon's fire on the move pointer, the movement factor is selected from the matrix. The basic (defilade) PK is multiplied by the movement factor to realize an adjusted PK value. The final PK value is tested against a randomly drawn value to determine a hit or miss of the target.

(6) Situation 6. The situation of a moving firer attempting to engage a moving target equipment follows the same order as described in Situation 3. The precedence is set in the order in which the program logic is invoked.

6-6. TACTICS

a. Maneuver unit tactics are handled within the small unit engagements (battles) through the use of "types" of battlefields. The type battles are, in essence, a representation of fire and maneuver (tactics) procedures and provide the necessary command and control for the units at this level of combat activity. In addition to the type battles, there are certain logical activities

performed within the local battle environment that are a part of the small unit engagement methodology.

b. The following descriptors are employed in the local battle environment in the model design.

(1) Unit Types

1 - Red tank platoon/company
2 - Red mechanized infantry platoon/company
3 - Blue tank platoon
4 - Red maneuver company headquarters
5 - Blue mechanized infantry platoon
6 - Blue maneuver company headquarters
7 - Red infantry platoon/company
8 - Blue infantry platoon
9 - Red attack helicopter team
10 - Blue attack helicopter team
11 - Blue close air support (CAS)
12 - Red CAS

(2) Unit Status

1 - Advancing (attacking)
2 - Withdrawing
3 - Stationary
4 - Moving
5 - Changing: advancing to withdraw
6 - Changing: Stationary to withdraw

6-7. BATTLE INITIATION

a. The aggressively moving force (posture) is the side that possesses the preponderance of move-to-coordinate orders, as created by the user. When proximity tests are satisfied (opponent unit distance at, or less than the activate battle range) an activate attack is triggered. The attacking task force is composed of the formation of units operating under the common order set and becomes a battle force. A check is made of the opponent units to determine which of those units are within the activate battle range. All opponent maneuver units found within the range, and those units that are in their common task force operating under the common order set, become defending units and are established as one battle force.

b. The exception to this procedure is those opponent units that are engaged in another, though in close proximity, battle. As these opponent battle forces are established, the following actions are accomplished.

(1) The battlefield terrain is established with a random draw from the list of available terrain types. The associated terrain descriptors for line of sight, moving fire ranges, defilade ranges, etc., will be employed for both battle forces for the duration of the battle.

(2) The mission of each drawn force is established as the mission of the first unit identified for each side. The mission (attack, defend, delay, patrol, ambush, and probe) is employed to establish the decision criteria (threshold percent of critical equipment) for the execution of actions to follow by each battle force.

(3) The quantity of combat critical equipment in each unit is summed for the force. The total quantity is employed as the numerator, and the type unit critical number of as the denominator in checks of the maneuver force's strength periodically in battle. The strength percent must be greater than or equal to the decision criteria for the force to execute the mission.

(4) The force composition is examined to compute an attack helicopter priority level for each force in the battle.

(5) A check of the available types of battles (prestored or templates) is made; the test for force composition in quantities, types of units and mission. If none is found, the general, or default, battle is invoked, which includes all of the units involved. Currently, only the default battle is used.

(6) The general battlefield is set up by computing the center of mass of each force and orienting each force on the center of mass of the opponent. The maneuver units formation that previously existed is dismissed, and an online, equally spaced formation of the opponent units is established with higher or headquarters maneuver units being set behind the online formation for each force. Based on the user specified battlefield width, distance to attack, and distance to withdraw, paths of attack or withdrawal are established for each unit of each force. The opening range between opponent units is adjusted (only reduced) to account for center of mass and orientation computations that may have increased the distances between forces.

(7) The battlefield events are set in motion by invoking the logic to:

- Establish line of sight between opponents.
- Establish detections of opponent units.
- Switch the indirect fire target sensings by forward observers from the overall battlefield to the local battle.
- Draw the helicopters into battle.
- Commence the initial movement of the units.

6-8. MANEUVER ON THE LOCAL BATTLEFIELD

a. The methodology for fire and maneuver brings together the two modeled concepts of paths as defined for each maneuver unit and line of sight segments for each maneuver unit. These concepts work in concert with the detection process which defines opponent units as "visible units" subject to direct fire engagements.

b. The concept of defining paths through a set of path points is unique to the small unit engagement portion of the methodology. The path points are established when the local battlefield is established. Through the sequence of minimum moves, moves, and change locations, the unit is either advanced or withdrawn along the route defined by the path points. The rate of movement is a function of the type terrain associated with the battle, the type unit movement rate, the day or night condition, and the tactical movement factor (see systems input). Units encountering minefields while in the battle are subject to delay while minefields are breached. Movement distances are driven by order sets.

c. In general, attacking units advance against defending units until they can no longer sustain the attack, in which case they may initiate a withdrawal, or the defending units fail to resist the attackers and commence a withdrawal. At each change of location, the battling units perform a

line of sight check with opponents. Also, proximity checks are performed by the defending units during the attacker moves to determine a point to initiate a withdrawal. Breakoff ranges are input and, if the attacker closes within the breakoff range, preparation is made to withdraw, followed by the unit's withdrawal. Concurrently, checks of the force's status are made to determine the overall continuation of the mission.

d. As the opponents establish line of sight, the logic for detections is invoked, whether moving or stationary. Searches are conducted by weapon systems for opponent unit equipments. As successful detections are made, the engagement logic, followed by the shootout logic, is employed to determine kills or misses. As kills are made, the assets of the targeted unit are assessed as losses, and the appropriate reductions in the unit's capability are made. Tests to decide the subsequent course of action are employed to determine the status of the force. Battle termination checks are made as assessments occur.

e. In the event engaged units reach a reinforcing threshold, they may initiate a request for reinforcements. The battlefield is searched for friendly maneuver units within the reinforcing range that are not elsewhere engaged in battle and possess sufficient (combat effective) assets. This unit and any subordinate maneuver units under its command are issued a reinforcing order and proceed to the battle area. When these units reach the activate battle range, the battle is interrupted to incorporate them in the battle force.

6-9. ASSESSMENT - COMBAT EFFECTIVENESS

a. Assessment during the small unit engagement is dynamic. The following types of assessments influence the battle outcome.

(1) Direct Fire. As shootouts are processed, the kills are registered on the unit and the materiel assets reduced.

(2) Helicopter Fire. The attack/scout teams acquire and engage targets on the battlefield, their direct fire kills are registered on the units, and the materiel assets are reduced.

(3) Indirect (artillery) Fire. The artillery called in the battle is assessed according to the coverage of the target unit by lethality. These kills are registered on the units and their materiel assets reduced.

(4) Minefields. Emplaced minefields or FASCAM attrite the unit encountering these hazards. The kills are registered and the unit's materiel assets reduced.

(5) Smoke Munitions. When employed, smoke reduces visibility and is modeled as reduced line of sight capability. This reduces the quantity of detections and engagements.

(6) Illumination Munitions. When employed, illumination improves visibility and is modeled as increased line of sight capability. This increases the quantity of detections and engagements.

b. Periodically, checks are made of each maneuver unit's combat effectiveness. If the quantity of critical equipment in the unit is reduced below the combat effective threshold, based on the type of unit, the unit is declared ineffective and removed from the task force to which it belongs. It is also removed from the side's order of battle hierarchy and moved instantly 20 kilometers to the rear of the battle area (FLOT).

6-10. BATTLE TERMINATION. As units are evaluated during the course of the battle, termination checks are made. A battle finish is established if the number of critical equipment items onhand falls below the prescribed threshold, given the mission and side, or if a breakoff range is penetrated. As the battle is ended, final in-process assessments are completed, any remaining fire missions or attack helicopter requests are terminated, and the remaining units return to their order sets for selection of the next appropriate order.

6-11. INITIAL MOVEMENT IN BATTLE. The logic for movement of the maneuver unit engaged in a battle is different from the command and control features discussed previously, in which units are given (from the user) sets of orders. The units in the battle maneuver along path points that have been previously described for them through the general battle scenario. The units follow a predefined set of points which define their route. The units within a battle make minimum moves (change of unit locations) as based upon a movement factor which is given by the type of terrain upon which the battle is conducted, the day or night movement factor, and the tactical movement factor. The unit is then moved by a series of events in computed time steps, based upon its speed on the terrain for the type of unit.

6-12. INDIRECT FIRES IN THE SMALL UNIT ENGAGEMENT. The forward observer activities at this juncture are altered to set the observer status with a flag indicating that he is in battle. All the previous detections that were candidates on his target report list are cleaned up, and the forward observer's focus is oriented to the battle and to the opponent units in the battle. All of the opponent units become detection candidates for the forward observer as he begins conducting searches. Periodically the forward observer is checked to determine if he has been destroyed. If the observer has been the victim of indirect fires or direct fires, he is then destroyed, and any target reports in process by the observer are cleaned up and destroyed.

6-13. REASONING AND LOGIC. The functional description provides the logic employed in modeling the small unit engagements.

6-14. LIMITATIONS AND ASSUMPTIONS. The small unit engagement methodology has been implemented with the following functional limitations and embodies the stated assumptions.

- The engagement methodology assumes that all range estimations between firer and target are correct; i.e., there is no distinction between those weapon systems that possess range finding devices and those that rely solely on the judgment of the weapon operator. Accurate range estimation is paramount in achieving direct fire kills.

- Withdrawing units move at a rate of three times their type of unit movement rate, regardless of other factors (terrain, day-night, etc.)

- The effects of indirect fires on detections and direct fire engagements do not include the suppressive (heads-down) effect.

- It is assumed that if line of sight exists between two opponent units, and one detects another, the second unit detects the first not later than when the first round impacts.

6-15. ALGORITHMS. None.

CHAPTER 7

HELICOPTERS

7-1. GENERAL

a. Helicopters are included in the simulation through the equipment description, the same as any other equipment such as tanks. In addition to this, the forward area rearm and refuel point (FARRP) must be established and assigned to a unit. Helicopters remain at the FARRP location until they are summoned into battle. While they are at the FARRP, helicopters are subject to the hazards of artillery fire. When in the FARRP area, helicopters may be members of rearm/refuel queues. Combat with helicopters is modeled in small unit battles. (Small unit battles are created and exist only when ground forces are engaged in direct fire combat.)

b. The simulation of helicopters considers the aspects of tactical employment, armament, configurations, rearm/refuel requirements, reliability, engagement procedures, coordination with the maneuver commander/FIST team and threats to the helicopter.

c. The attack helicopter team may consist of either autonomous attack helicopters or a scout/attack helicopter mix employed in battles as scout/attack partners.

d. Two types of data input are required that are specifically for the simulation of helicopters. The first type of data is that used to describe the helicopters as equipment with weapons, maximum speed, cross sectional area, probabilities of kill, etc. This type of data is *exactly* the same as required for other equipment such as a tank that is in the simulation. This input is described elsewhere in this document. The second type of data is that used to describe the helicopters only. These data primarily describe the FARRP.

e. The FARRP is modeled as a set of data elements that must be associated with a unit. This unit must have helicopters in the equipment list. When the helicopters are being used, the FARRP data controls the employment.

7-2. EMPLOYMENT

a. The helicopters are not employed during the simulation unless a unit engagement is in process. When the battle begins, a priority of employment for helicopters is computed. A separate computation is made for Red and for Blue. If the priority is greater than zero, a search is made to determine if any FARRP is available. The selection is the closest FARRP that is not engaged in another battle and for which the loiter time at the battle will be greater than zero. If a FARRP is selected, that FARRP will not be selected to support another battle until it leaves the current battle. In addition, the side that is receiving helicopter support will not request additional helicopter support in the same battle. If no FARRP can be found, the priority is stored and the small unit engagement proceeds. The start of the battle causes the helicopters to organize into teams. If there are more than three attack helicopters, three teams are formed. If there are one or two attack helicopters, there are one or two teams formed, respectively. The attack and scout helicopters are distributed as evenly as possible among the teams. The first team leaves for the battle immediately while the second and third teams wait one and two times the loiter time of the first team. The teams going to the battle must wait the time to fly to the battle before they can begin fighting.

b. When a team arrives at a battle, a check is made to determine if a team is presently engaged. If a team is already in the battle, it is returned to the FARRP. The time to return to the FARRP is the flight time for the distance to be traveled. Helicopters position themselves in a

battle so that they are behind the maneuver units and the range to the closest opposing unit is a fraction of the maximum standoff range of the helicopter's longest-range weapon. The exact fraction will be drawn from a uniform distribution over a user-specified range of values (e.g., .7 to .9). This simulates the coordination of the helicopter's positions to those of the supported maneuver units by the maneuver commander/FIST team.

c. When the team is in position, the entire team cycles through five operations--pairing, unmasking, waiting unmask time, masking, and waiting mask time. The pairing operation consists of pairing attack helicopters with scouts. The helicopters then unmask and either acquire targets or engage targets already acquired. When the helicopters unmask, they are subject to being acquired by the ground units. When the time to remain unmasked is over, the team remasks. This remasking stops firing between ground units and the helicopters and causes the ground units to "forget" about the helicopters. This operation models the movement of the helicopters prior to unmasking. The helicopters "remember" the targets that have been acquired and can immediately engage upon unmasking. The helicopters remain masked for the time period and then cycle back through this process.

d. When the team has exhausted its ammunition or is about to exhaust its fuel or when another team arrives at the battle, the team returns to the FARRP. Upon arriving at the FARRP, noncombat failures are computed and subtracted from the helicopters available. (The data may be constructed to always have zero failures.) The helicopters wait to refuel and rearm and then prepare to return to the battle. If the battle is concluded, then all of the current battles are checked to see if helicopter support is required. This is accomplished by examining the helicopter priorities that have been set. The highest priority battle is supported if the helicopters have a nonzero loiter time at the battle. If no battle for the helicopters is found, the helicopters remain at the unit with the FARRP until needed.

e. The engagement of ground units by helicopters and of helicopters by ground units is basically the same as for engagements between ground units. For that reason, this logic will not be discussed in detail here. However, the helicopter team's expenditure of ammunition is limited to the basic load until the team returns to the FARRP and is rearmed.

f. Helicopters leave the battle when the battle is terminated or the opposing force starts to withdraw.

7-3. REASONING AND LOGIC. The functional description provides the reasoning incorporated in the methodology.

7-4. LIMITATIONS AND ASSUMPTIONS

a. Within a single unit, all attack helicopters must be configured with identical weapon systems.

b. The unit with helicopters can only have one type of equipment with weapons and that type of equipment must be the attack helicopter.

c. As helicopters never gain a significant altitude in battle, range differences introduced by modeling them in a two-dimensional battleground are not considered.

d. The unit which owns the helicopters always has enough personnel to adequately operate helicopters.

e. The use of small unit engagement target selection procedures simulates the target selection and fire coordination processes that exist between the maneuver commander/FIST team and helicopters.

f. The priority scheme for employment of helicopters in battle models the request/allocation procedures used by the maneuver commander/FIST team.

g. The helicopter teams redistribute the helicopters among teams only if they all return to the FARRP prior to supporting another battle.

h. A helicopter team with no attack helicopters does not return to the battle once it reaches the FARRP.

i. For simulation purposes, the FARRP and lager area will be considered the same.

j. Helicopters in battle may be killed by ADA only when unmasked.

k. One helicopter unit on a side can be in one small battle at a time. The composition of the helicopter unit is a user input.

7-5. ALGORITHMS. Each battlefield has a priority for helicopter employment (P) which is calculated according to the formula.

$$P = P1 * P2 * P3 * P4$$

where

P = HB.PRIORITY = helicopter employment priority for the battle

P1 = SUP.MISSION.PRIORITY = priority number of the mission of the support force (user input)

P2 = NO.SUP.UNIT = MAX.F (0, TOTAL.NO.SUP.UNIT - (MIN.NO.SUP.UNITS-1)) if force is Blue

TOTAL.NO.SUP UNITS = the total number of supported units

MIN.NO.SUP.UNITS = the minimum number of units a force must have to be considered for helicopter support (user input)

P2 = NO.SUP.UNITS. = the total number of support units if force is Red

P3 = the total of TU.SUP.PRIORITY (a user input) for each unit in the force

P4 = the total of TU.OPP.PRIORITY for each unit in the opposing force

CHAPTER 8

MINEFIELDS

8-1. GENERAL

a. Minefields are viewed as a delay in a unit's movement. Attrition of the unit penetrating the minefield occurs. Once losses from a minefield have occurred, a delay in the unit's movement is assumed to allow the unit time to clear paths through the minefield. During this period, both attacker and defender continue to fire at their normal rates. After the delay, the attacker is assumed to be through the minefield.

b. Two types of minefields are considered--barrier minefields and point minefields. Barrier minefields comprise hand emplaced mines, helicopter emplaced mines, GEMSS, GATOR, and MOPMS (to close gaps). The size and placement of barrier minefields are user-input quantities. Additionally, barrier minefields have a color. The color factor allows friendly units to traverse the minefield freely. Opposing units incur delays at minefields of opposite color. The effect of the color factor for barrier minefields is to simulate withdrawal lanes which are closed by FASCAM.

c. Point minefields are used to slow an attacker or withdrawing defender. Point minefields have a color, a limited size, and a limited duration. This means that point minefields affect one and only one unit on the opposing side. Other enemy units and all friendly units are not affected. Point minefields are comprised of RAAM, ADAM ,and MOPMS.

d. Artillery suppression is also simulated using FASCAM. The last volley (user input) of a counterbattery fire mission will be RAAM and ADAM rounds. The opposing battery is assumed to be suppressed for some time.

8-2. BARRIER MINEFIELDS

a. Barrier minefields are effective for the entire simulation against any enemy unit. The first type of movement is for an artillery unit. START.ARTY.MOVEMENT calls CHECK.FOR.MINES to locate any enemy minefields in the unit's path. Since a unit is assumed to maneuver around any minefields previously hit, the AU.LIST of the minefield is checked for the unit's ID. If it is found, the minefield is ignored. If it is not found, attrition occurs against the unit and a delay time computed. The delays are totaled and are added to the time at which the STOP.ARTY.MOVEMENT is scheduled.

b. The second type of movement is for a task force. START.MOVE also calls CHECK.FOR.MINES to locate any minefields in the path of the task force which have not been encountered before. Since a task force moves in steps, attrition does not occur when a minefield is found. Instead, a MINE.OBSTACLE pointing to the minefield is added to the task force leader's MO.LIST. Each time UPDATE.LOC is called to move the force forward a step, the list

is checked for any minefields which will be encountered in that step. Attrition occurs and the delay caused is added to the time required to make that step. Attrition will only occur to one unit, which is assumed to warn the others. If there is more than one unit in the task force, a unit other than the leader is randomly chosen to be attrited, the assumption being that the leader will be behind the other units.

c. At the time of attrition, the task force leader of the artillery unit is added to the AU.LIST of the minefield to prevent future encounters. If the task force leader is ever destroyed, each AU.LIST which has the leader is changed to point to the new leader.

d. Units delayed by a minefield while in a battle are assumed to be exposed (i.e., not in defilade) for direct fire weapon PK computations.

8-3. POINT MINEFIELDS

a. Point minefields are either artillery-delivered or MOPMS. They occur in a small battle, as part of counterbattery fire, or as a way to reseed breached barrier minefields. In the last case, they are always requested when a barrier minefield has been breached, do not cause casualties, but do place a load on the batteries.

b. For point minefields to be used, FASCAM munitions must be assigned to the batteries or MOPMS given to a unit. Also, the rules of use must be set. The possible rules are:

(1) An attacking force will request FASCAM to slow a defender who is starting to withdraw.

(2) A defending force will request FASCAM against the closest attacker.

(3) A defending unit will request FASCAM against the closest attacker at the start of withdrawal.

c. Each side and mission is either assigned a zero--no mines are to be requested--or the appropriate rule.

d. At the start of an engagement, the defending force is checked to see if rule 2 is in effect. If so, an artillery mission of type FASCAM is requested. Similarly, at the start of a withdrawal, the attacking force is checked to see if rule 1 is in effect, and the defender is checked for rule 3. If appropriate, artillery-delivered FASCAM is requested. If a request duplicates a mission in progress, the request is ignored. From then on, the mission is handled as other artillery missions.

e. FASCAM is only requested if the targeted unit and the requesting force are between MIN.FASCAM.RANGE and MAX.FASCAM.RANGE apart. In the case of rule 3, if the withdrawing unit cannot request FASCAM because the enemy is too close, it checks its weapons list for MOPMS. If available, it is employed and affects the target the same as the artillery delivered mines.

f. Each unit maintains a count of the number of times it has been hit by FASCAM. Each time a unit is targeted, the count is compared to the maximum allowable times. If the maximum has already been reached, the new request is ignored.

g. Delays are added to the UN.DELAY of the target. CHANGE.LOC checks the amount of time since the last move and subtracts this from the UN.DELAY. If the delay is greater than zero, no move occurs, and the next MOVE.UNIT is scheduled.

8-4. DELAYS

a. The delay times previously mentioned are based on the type of unit entering the minefield and its distance from the closest enemy forward observer. The delay computations are the same for all types of mines.

b. First, the closest enemy forward observer is found. This range is compared to each MFB.UPPER.LIMIT to see which of the three MF.BANDs apply. The MF.BAND gives the mean delay time. A random number drawn from a uniform distribution is then used to determine the actual delay. This is multiplied by the TU.MF.FACTOR of the type unit to relate the delay time to the kind of unit being affected.

8-5. ATTRITION

a. If personnel are present in the chosen unit, a random number drawn between minimum and maximum limits input by the user of the model determines the number of personnel killed. Two sets of min/max values are used--one for minefields which are delivered or reseeded by artillery, and another set for all other minefields.

b. A second type of equipment is also selected for attrition. If the minefield was delivered or reseeded by artillery, the type is chosen at random; for all other types, the unit's "principal type equipment" (a type input by the user) is chosen. As with personnel, the number of pieces of equipment destroyed is a random number drawn between minimum and maximum values input by the user and depends on whether the minefield was delivered or reseeded by artillery. The min/max values may also be different for different types of equipment.

8-6. SUPPRESSION. When artillery-delivered mines are included in the simulation and the type battery has FASCAM in its munition list, counterbattery artillery missions are assumed to have FASCAM in addition to the explosive rounds. Attrition computations are not affected. The targeted battery has its fire suppressed for a length of time randomly chosen from the interval TB.MN.FASCAM.SUPP to TB.MX.FASCAM.SUPP.

8-7. REASONING AND LOGIC. The functional description presents the reasoning employed in developing the design.

8-8. LIMITATIONS AND ASSUMPTIONS

a. Barrier Minefields. Once a unit has hit a minefield, it is assumed that the unit remembers the location and will maneuver to avoid it in the future. In the case of a task force, the entire force is assumed to be aware of a minefield that any unit in the force has encountered.

b. Point Minefields. Point minefields only occur in a battle or in counterbattery fire. The use of artillery-delivered mines against an enemy artillery unit is assumed to occur whenever the firing battery has FASCAM. Counterbattery fire is assumed to include a mixture of explosive rounds and mines. Attrition computations do not change, but the suppression time for the targeted artillery unit is increased.

c. All artillery-delivered mines are explicitly modeled as FASCAM assigned to a type battery. These are used when conditions occur as described by the rules of use. Also, when a barrier minefield has been breached, an artillery mission is requested to reseed the field. This will not cause casualties but will place a load on the batteries.

d. If MOPMS have been assigned to a unit which is directed to call for FASCAM upon withdrawal (rule 3) and if the closest enemy is less than the MIN.FASCAM.RANGE, the MOPMS will be employed instead of calling for an artillery mission.

e. In the case of MOPMS, once employed they are assumed to be immediately effective against the targeted unit. Artillery-delivered mines are assumed to be effective as soon as delivered. In both cases, the targeted unit is always assumed to encounter the delivered minefield. Attrition occurs upon delivery, since the time difference between then and when the target would actually encounter a minefield delivered in front of it is assumed to be small with respect to the time scale of the battle.

8-9. ALGORITHMS. None.

CHAPTER 9

VISIBILITY

9-1. GENERAL

a. Each of the visibility conditions to be modeled (smoke, dust, haze, fog, mist, rain, snow, and illumination) can be categorized in one of three general approaches. The first is a visibility degradation that has a localized effect. The second is visibility degradation that has a general effect. The third is a visibility enhancement that has a localized effect.

b. The localized visibility degradation, which is used for smoke, is modeled as an interruption to the line of sight: the employment of smoke causes a temporary loss of visible targets. The rules for employment of smoke and the effects of smoke are included in the small unit engagement routines.

c. The generalized visibility degradation, which is used for dust, fog, mist, rain, and snow, is modeled as an overall reduction in the performance of target acquisition. This reduction applies to the entire simulated force for the duration of the condition. The effect to each type of system may be different.

d. The localized visibility enhancement, which is used for illumination, is modeled as a temporary localized increase in light level. For the duration of the illumination in a localized area, the detection of the units in the area is modeled according to the increased light level.

e. The COSAGE simulation uses the Floyd Hill detection model for searches made by forward observers. This search model is not applicable to other than optical sensors and would be of dubious value in limited visibility conditions. The approach therefore is to replace the Floyd Hill scheme with a search model developed by the US Army Center for Night Vision and Electro-optics (CNVEO) for detections by operators of weapon systems. This model contains provisions for optical, image intensifier and infrared searches. The time-to-detect for the CNVEO model is an exponentially distributed random variable. This scheme requires that each sensor be declared as to type (optical, image intensifier, or infrared).

9-2. FUNCTIONAL DESCRIPTION. The modeling incorporates the following functional features.

a. Dust. Dust occurs each time high-explosive artillery rounds are used. As part of the computations of the effect of the rounds, an impact point is calculated. Also, the radius of the dust cloud generated by the artillery mission along with its duration is determined by the type of munitions used. These values are passed to routine DUST.EFFECTS, which determines if line of sight between the target unit and any enemy unit is broken. If it is, BLOCK.LOS is called. This routine puts each of the two units on non-LOS segments for the duration of the cloud. If the two units were in an engagement, the fighting is stopped and all associated processes and events are ended. After all lines of sight have been checked, a new MOVE.UNIT is scheduled for each unit which had its segments changed.

b. Illumination

(1) Illumination may be requested only at night and only when a side has one of the illumination rules set. The possible rules are:

(a) An attacking force requests illumination over the defending force.

(b) An attacking unit requests illumination over itself.

(c) A defending force requests illumination over the closest attackers.

(2) Each side and mission may have either an appropriate rule or no rule, indicating a unit with that mission may not request illumination.

(3) Illumination artillery missions are requested at the start of an engagement. The attacker is checked to see if rule 1 or 2 is in effect and the defender is checked for rule 3. Illumination missions already in progress are checked to see if the new mission duplicates previous actions. If so, the new request is ignored. Once the mission has been requested, it is processed as for any other artillery unit.

(4) When the rounds arrive, assuming it is still night, conditions are temporarily set to day. The time to detect any of the units which were lighted is computed and engagements are scheduled. The light is then reset to night and the simulation continues.

(5) Identical missions will then be requested until the requester starts to withdraw, the battle ends, or day arrives.

c. Smoke

(1) Smoke may be requested in either night or day. As with illumination, each side and mission has a rule concerning the use of smoke. The possible rules are:

(a) An attacking force requests smoke to block the entire defending force.

(b) An attacking force requests smoke to block the closest defender.

(c) A defending force requests smoke to block all but the closest attackers.

(d) A defending unit requests smoke to block itself when it starts to withdraw.

(2) At the beginning of an engagement, the attacking and defending forces are checked to see if they have a smoke rule in effect. If so, current smoke missions are checked to see if the new request will duplicate a mission in progress. If not, a TARGET REPORT is activated to start the artillery mission. Also, when a defending unit begins to withdraw, it checks to see if rule 4 is in effect and, if so, requests smoke.

(3) The smoke mission is handled similarly to other artillery missions until the rounds have arrived on target, when SMOKE.EFFECTS is called. This routine updates the position of all units in the battle. Then, all opposing pairs of units are placed on non-line-of-sight segments for the duration of the smoke. BLOCK.LOS is called to end ENGAGEMENTS and all associated processes and events. A new MOVE.UNIT is scheduled for each unit which had its segment lengths adjusted. Except for the case of rule 4, a new smoke mission is requested to repeat the effects of the mission just completed. The missions will continue until the battle is ended.

9-3. REASONING AND LOGIC. The functional description provides the features of the design reasoning.

9-4. LIMITATIONS AND ASSUMPTIONS

a. Smoke and illumination are assumed to be effective whenever they reach the target.

b. The munitions will always land on target and create the situation that was requested.

c. If more rounds than the maximum number permitted are needed for the mission, the maximum allowed are fired.

d. The munitions are assumed to be targeted in such a way as to have the same effect as would firing all the required rounds.

9-5. ALGORITHMS. None.

CHAPTER 10

TACTICAL AIR SUPPORT/AIR DEFENSE (TACAIR/AD)

10-1. GENERAL

a. The TACAIR/AD function represents the activities of fixed wing aircraft operating in support of ground forces and the activities of ground based air defense systems against aircraft and helicopters. Air activities modeled include close air support (CAS) and battlefield air interdiction (BAI) missions. CAS is air action against hostile ground targets, requested by the ground commander, which requires detailed integration with the maneuver and fire support plans of the ground commander. BAI is air action against enemy forces and resources that are in a position to influence and affect ongoing land operations, but which are not yet directly engaged; BAI missions require joint coordination but do not require detailed integration with the ground commander's plans.

b. Only ground-based AD activities located within the COSAGE boundaries are modeled. Air-to-air action is not modeled, except for helicopter versus helicopter engagements.

c. Both preplanned and on call TACAIR missions are modeled. The user must specify the time and target unit for preplanned missions. Requirements for oncall missions are generated automatically during battles whenever certain thresholds are exceeded.

d. Aircraft are vulnerable to air defense systems while flying to and from the target and while making the attack on the target. Systems other than air defense may also fire on the aircraft during an attack.

e. All of the aircraft on a side are located in a single unit, known as the AIRFIELD. In selecting a flight path from the AIRFIELD to the target, aircraft attempt to avoid known enemy AD sensors. The flight path consists of a series of straight-line segments.

f. User input specifies a number of TACAIR mission constraints. These include a maximum number of sorties for each aircraft type, a sortie rate, airspace redirections, and weather conditions. The user specifies the maximum number of sorties per unit time, the maximum number of sorties within a selected radius, and the minimum flying visibility. If a mission cannot be flown because of a constraint, the mission is placed in a queue to be flown later, if possible.

g. AD systems may be represented as equipment assigned to a unit or as weapons on a piece of equipment.

h. The TACAIR/AD input is divided into three data sets: aircraft munitions (AC.MUNS.INPUT), model air defense sensors (MADS.INPUT), and TACAIR (TACAIR.INPUT). These data files are described in Vol II of this User's Manual.

10-2. MISSION GENERATION

a. Preplanned TACAIR missions. Preplanned missions are generated as a result of user input to the TACAIR file. The user specifies the unit to be attacked, the time of the attack, and the type and number of aircraft to conduct the attack.

b. Oncall TACAIR mission. Oncall missions are generated as a result of ongoing battle. The target unit for oncall missions is selected from enemy units in the battle. Selection of the target unit is based on a ratio of friendly to enemy criteria equipments. The philosophy is to support units facing imminent defeat or to exploit an advantage.

c. Only one CAS mission can support a side in a given battle at one time, but subsequent missions may be called if the thresholds remain exceeded after a mission is complete.

10-3. MISSION CONSTRAINTS

a. TACAIR missions may be constrained by user input. The possible reasons a mission may not be flown when required are:

(1) No More Sorties Available. The user inputs the number of sorties of each AC.TYPE as the UE.OUANT for the corresponding equipment in the UNIT Data file. If no sorties are available for the primary type aircraft, an attempt is made to fly the mission with a substitute AC.TYPE. The user specifies the ACT.SUBSTITUTE on input. If the substitute is also not available, the mission is canceled, and a report is written.

(2) Weather. The user inputs the minimum flying visibility, NO.FLY.VIS. The user controls visibility with input for CHANGE.WEATHER.

(3) Night Time. TACAIR missions are flown only during the day. This is controlled by user input for CHANGE.LITE.

(4) Sortie Rate. The user inputs the maximum number of sorties to be flown in a specified time period. The user also inputs the length of the time period. When the maximum is reached, no more sorties are flown until the end of the time period.

(5) Airspace Constraint. The user inputs the maximum number of sorties that can be active within a given radius. The user also specifies the radius.

b. If the mission cannot be flown for any reason other than lack of aircraft, the mission is placed in a queue to be flown later, if possible. The status of the CMSN.QUEUE is checked whenever the weather changes, the light changes, a sortie rate time period ends, or a mission frees airspace by completing its attack.

10-4. FLIGHT PATH SELECTION

a. Each flight path consists of straight-line segments. The simplest flight path consists of the single straight-line segment between the AIRFIELD and the target. However, intelligence about enemy AD sites will result in a changed flight path if the simplest path would intersect any known sites.

b. Intelligence about enemy AD sites is gained whenever an aircraft is fired on during the flight to or from the target. The philosophy here is that the pilot reports back to his base when he is fired on. Intelligence is not gained about AD sites that fire during an attack because the aircraft expects to be fired on at this time.

c. If intelligence about enemy AD sites is available, the flight path attempts to circumvent the known sites.

d. If the selected flight path intersects any enemy AD sites (known or unknown), appropriate AD engagements are scheduled.

10-5. AIR DEFENSE ENGAGEMENT

a. Air defense sensors are modeled as concentric cylinders, each with a range, minimum altitude, and probability of detection. If a flight path intersects the sensor, the aircraft may be detected, depending on the probability of detection at the closest range. If detection occurs, the time of detection is determined stochastically as follows: time of detection is a normal random variable with the mean equal to 1/2 T and the standard deviation equal to 1/4 T, where T is the time during which the aircraft is inside the sensor acquisition capability. A delay is imposed after detection before firing. The user inputs the delay time for each system.

b. Air defense weapons fire at the aircraft until it is out of range or a hit is made. The user inputs the fire control method to be used by each AD weapon: shoot-look-shoot, ripple, or salvo. The delay time between firings is based on the fire control method. Ammunition expenditures are recorded, and kills are recorded on the KV scoreboard.

c. Detection and firing at aircraft during an attack are modeled differently and are discussed in paragraph 10-6.

10-6. AIRCRAFT ATTACK TARGET

a. The interaction between the aircraft and ground weapons is modeled explicitly in a manner analogous to the interaction between ground systems.

b. All the aircraft in a mission are assumed to arrive at the target simultaneously. Each aircraft then makes multiple passes at the target along a triangular attack profile which is specified by the user. The number of passes is determined as the number of blind passes plus the sum of the number of firing passes for each weapon. Blind passes are made only when the target is not engaged in a battle, in which case forward air control is not available and the aircraft must precisely locate the target. The number of blind passes is determined by the user input target acquisition delay time for each aircraft. For each weapon, the number of passes is the quotient of the number of rounds (WPN.QUANTITY) divided by rounds fired per pass. On each pass, the aircraft is vulnerable to ground fire between point P1 and point P3 and is assumed to be invisible from point P3 to point P1. The target unit must detect the aircraft on each pass. Detection time is an exponential random variable with the mean equal to the minimum TW.AC.DET.TIME of all weapons in the target unit. The aircraft delivers its ordnance at a selected firing point located between P1 and P2. The firing point is determined as a random variable uniformly distributed between TW.MIN.RANGE and TW.MAX.RANGE. The aircraft may deliver point target fire (e.g., rockets and missiles) or area fire (bombs). The target for point target fire is selected from all the nonpersonnel equipment in the target unit. The selection is made uniformly over the sum of the projected area (TE.PROJECTED.AREA) of all nonpersonnel equipment. The philosophy is that the pilot selects the largest target he sees and does not have time to differentiate between equipments. The effects are modeled in accordance with the methodology for direct fire

described in Chapter 6. Indirect fire effects are modeled in accordance with the methodology for indirect fire described in Chapter 4.

c. If there is an area AD unit within range of the attacking aircraft, it will support the target unit by firing on the aircraft while it is visible on each pass.

d. AD equipment in the target unit will attempt to engage the aircraft during the attack and will not attempt to fire on ground targets. Other equipment in the target unit may attempt to engage the aircraft in accordance with the rules for target selection outlined in Chapter 5.

10-7. REASONING AND LOGIC. A key feature of the TACAIR/AD function is its adherence to the COSAGE data hierarchy of units, equipment and weapons. An exception occurs with the AIRFIELD. UE.QUANT is reduced whenever a sortie is assigned to a mission. The philosophy here is that Air Force resources are controlled at the sortie level, not by individual aircraft. One sortie equals one flight by one aircraft, but the same aircraft may fly several sorties in 1 day.

10-8. ASSUMPTIONS AND LIMITATIONS

a. ECM and ECCM are not played directly. However, commensurate with COSAGE rationale, these activities may be reflected indirectly by appropriate adjustments to input data.

b. TACAIR will *not* attack helicopters, and vice versa.

c. When making an attack, TACAIR has line of sight (LOS) to target. Concomitantly, the attack unit has line of sight to the AC after detection.

d. TACAIR knows the location of each element of target for CAS mission. This is equivalent to being guided by a forward air controller (FAC). TACAIR will incur a delay to acquire target elements for BAI mission.

e. Aerial refueling is not modeled.

f. Air defense sensors provide target information only to associated AD weapons. That is, unless AD is given a sensor capability, only visual target acquisition will occur.

g. Sortie loss due to causes other than ground based enemy AD is not modeled directly but is accounted for stochastically by ACT.PROB.SORTIE.ABORT.

h. AD weapons are in weapons tight status, but AD will not detect or fire on friendly TACAIR. Identification friend or foe (IFF) is not modeled.

i. Killed TACAIR are not repaired.

j. AD outside of COSAGE boundaries does not fire on CAS/BAI missions inside COSAGE boundaries.

k. Evasive action by TACAIR when encountering AD is not modeled directly, but may be reflected by appropriate adjustment in input data.

l. If one or more aircraft in a multi-sortie mission is killed, the surviving aircraft continue the mission.

m. AD weapons not associated with a sensor capability (other than operating personnel) fire shoot-look-shoot.

APPENDIX A

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APPENDIX B

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APPENDIX C

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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

ADA	air defense artillery
ADAM	area denial artillery munition
AO	aerial observer
ATCAL	Attrition Calibration (model)
ATGM	antitank guided missile
BAI	battlefield air interdiction
BMNT	beginning morning nautical twilight
CAA	US Army Concepts Analysis Agency
CB	counterbattery
CEM	Concepts Evaluation Model
CEP	circular error probable
CFR	counterfire radar operator
CM	countermortar
CNVEO	US Army Center for Night Vision and Electro-optics
COSAGE	Combat Sample Generator (model)
CS	combat support
DFFB	distance from FLOT bands
DS	direct support
ECCM	electronic counter-countermeasure(s)
ECM	electronic countermeasure(s)
EENT	end evening nautical twilight
FAC	forward air controller
FARRP	forward area rearm and refuel point
FASCAM	family of scatterable mines
FDC	fire direction center

FIST	fire support team
FL	flash
FLOT	forward line of own troops
FO	forward observer
FORCEM	Force Evaluation Model
GATOR	TACAIR-delivered scatterable mines
GEMSS	ground emplaced mine scattering system
GS	general support
GSR	general support reinforcing; ground surveillance radar
HE	high explosive
ICM	improved conventional munition(s)
JSEAD	joint suppression of enemy air defense
K/V	killer/victim
LCM	life cycle management
LGM	laser guided munitions
LOS	line of sight
MOBA	military operation in built-up areas
MOPMS	modular pack mine system
MT	megaton(s)
PD	probability of detection
PDB	passive detection base
POL	petroleum, oils, and lubricants
PGM	precision guided munitions
RAAM	remote antiarmor mine system
RALPH	Reduction ATCAL Linkage Phase I
RAM	reliability, availability, and maintainability
RAP	rocket assisted projectile

RPV	remotely piloted vehicle (old name; see UAV)
SADARM	sense and destroy armor
SD	sound
TACAIR	tactical air
TOE	table(s) of organization and equipment
TOT	time on target
UAV	unmanned air vehicle
VT	variable timing